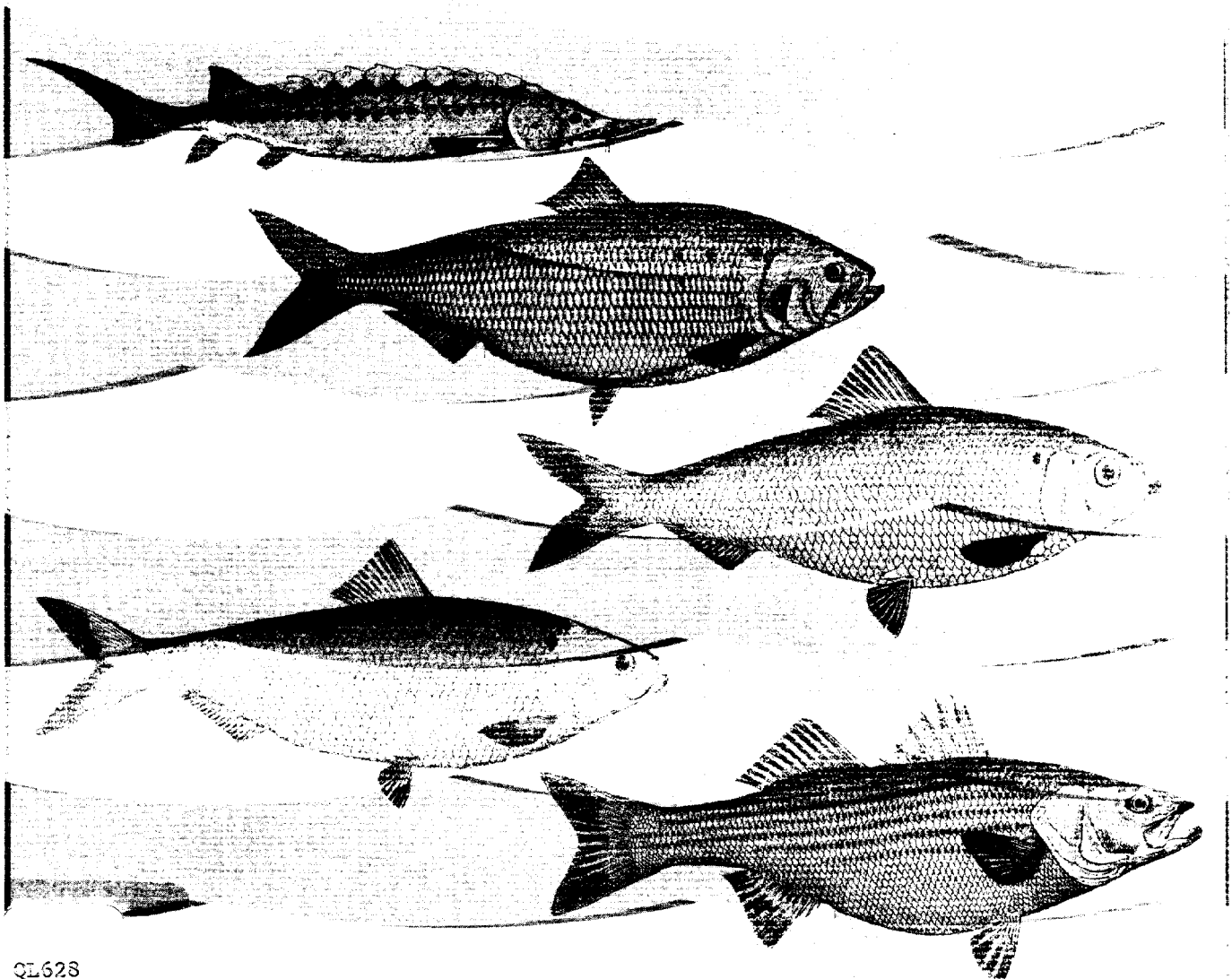
DISTRIBUTION AND BIOLOGICAL STUDIES OF ANADROMOUS FISHES OFFSHORE NORTH CAROLINA



DIVISION OF COMMERCIAL AND SPORTS FISHERIES
NORTH CAROLINA DEPARTMENT OF NATURAL & ECONOMIC RESOURCES

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NORTH CAROLINA DEPARTMENT OF NATURAL AND ECONOMIC RESOURCES

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DISTRIBUTION AND BIOLOGICAL STUDIES OF ANADROMOUS FISHES OFFSHORE NORTH CAROLINA

by

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ABSTRACT

During the period 1 February 1968 to 1 July 1971, the R/V Dan Moore occupied 1,038 trawl stations from Cape Romain, South Carolina, to Cape Charles, Virginia, in depths of 3 to 300 fathoms. A total of 9,734 anadromous fishes was collected. Striped bass (Morone saxatilis), blueback herring (Alosa aestivalis), and a few hickory shad (Alosa mediocris) were found between Cape Lookout and the North Carolina/Virginia border. American shad (Alosa sapidissima) and alewife (Alosa pseudoharengus) were taken from Hatteras Inlet and from Wimble Shoals, North Carolina, to Cape Charles, Virginia. Two species of sturgeon, Acipenser oxyrhynchus and Acipenser brevirostrum, were collected mainly between Cape Lookout and North Carolina/Virginia border. Definite seasonal differences in abundance were noted in the ocean off North Carolina. Anadromous fishes were most abundant from December through March. Few anadromous fishes were collected in depths of more than 20 fathoms. Scale analyses of 290 striped bass, 134 American shad, 76 blueback herring and 50 alewife indicated these fish ranged from 2 to 15, 2 to 11, 2 to 8, and 4 to 8 years old, respectively. Growth and size relationships were also determined. The peak annulus formation for striped bass, probably occurs in early December. A total of 3,147 anadromous fishes was tagged. As of 1 November 1971, no tags had been returned from any of the 1,204 clupeids tagged. Tag returns from the 187 tagged Atlantic sturgeon indicated a seasonal migration southward during November-January and northward after January. A total of 1,752 striped bass was tagged. As of 1 November 1971, 197 tags had been returned. Tag returns indicated that striped bass overwintering off the North Carolina coast enter Pamlico and Albemarle Sounds, and move northward along the Atlantic coast to Maine during the spring and summer. An annual fishing mortality rate of 35 percent for striped bass was projected from the 3.6 percent mean monthly rate. Stomach analyses indicated that striped bass remain active and opportunistic feeders during the winter. Adult American shad eat fish, sometimes to the extent that they can be considered a major food item. Juvenile American shad feed occasionally on anchovies. The mean fecundity of 35 striped bass was 2,462,372. The mean fecundity of 43 American shad was 281,137. Examination of the gonads of striped bass, American shad, blueback herring and alewife revealed a predominance of female striped bass, American shad, alewife and male blueback herring in the ocean off North Carolina. Sampling among foreign fishing vessels revealed that the East Germans and others were taking anadromous fishes off the North Carolina coast. Offshore and Chowan River samples of blueback herring and alewife were compared, and similarities and differences were noted utilizing age class composition and length-weight relationships.

INTRODUCTION

Anadromous fishes constitute an important part of the annual North Carolina finfish landings. These fishes, particularly striped bass (Morone saxatilis), American shad (Alosa sapidissima), hickory shad (Alosa mediocris), and river herring (Alosa aestivalis and Alosa pseudoharengus) are caught in the ocean, estuaries, and freshwater streams by a variety of commercial gear including otter trawls, gill nets, pound nets, purse seines and haul seines. The Atlantic sturgeon (Acipenser oxyrhynchus) and the shortnose sturgeon (Acipenser brevirostrum) have minimal local commercial value at present and are caught only incidentally to other fisheries.

Some research has been conducted on American shad in North Carolina, particularly in Neuse River (Walburg, 1957) and Cape Fear River (Davis and Cheek, 1967; Nichols and Louder, 1970). Striped bass have been studied extensively in Roanoke River (McCoy, 1959; Cheek, 1961; Hassler, Hogarth and Liner, 1967; Trent and Hassler, 1968; Hassler and Hogarth 1970). Juvenile river herring have been collected in Cape Fear River (Davis and Cheek, 1967). These studies have been concerned with adult fish, eggs, larvae, or juveniles. Except for the striped bass studies by Chapoton and Sykes (1961) and Clark (1968), and Netzel and Stanek (1966) on river herring, little is known about anadromous fishes between the time they leave the river systems as juveniles and return later as adults to spawn.

The commercial fisheries for anadromous fishes in North Carolina have traditionally been located in the estuaries and inland rivers. Beginning in 1967, however, a trawl fishery for striped bass developed in the ocean along the outer banks from Oregon Inlet north to the North Carolina/Virginia border.

In 1968, the State of North Carolina, utilizing its new 85-ft. exploratory fishing vessel, the R/V Dan Moore (Figure 1), with the support of the U. S. Bureau of Commercial Fisheries (now the National Marine Fisheries Service), began

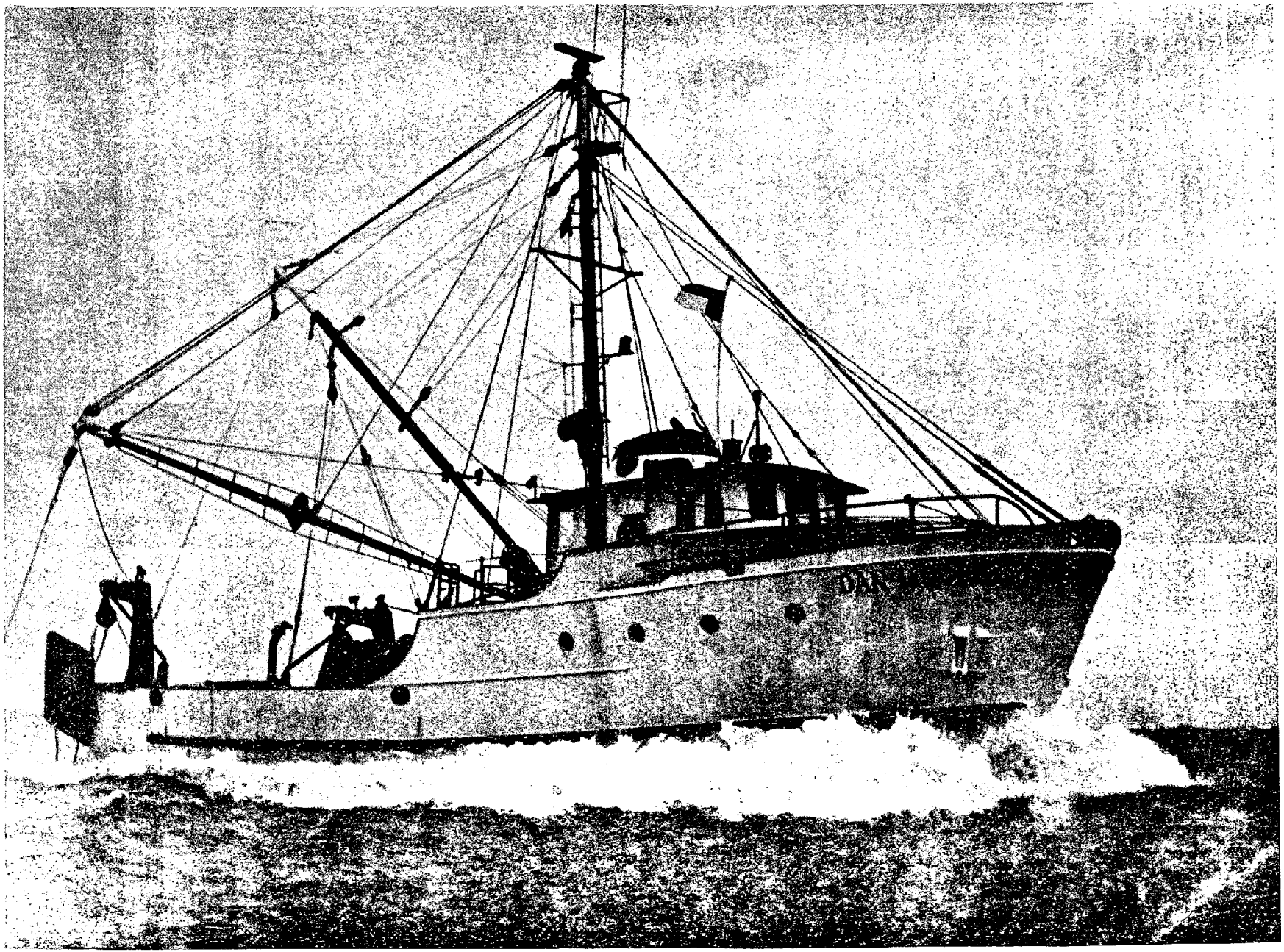


Figure 1.--The R/V Dan Moore North Carolina's 85-ft. exploratory fishing vessel.

a three-year survey of anadromous fishes along the coast of North Carolina. The first segment of the project, reported by Sterling and Godwin (1970), was conducted from 1 February 1968 to 30 March 1969 and was concerned mainly with gear testing, location of concentrations of anadromous fishes along the coast, and tagging. The second segment, reported by Holland and Street (1970), was conducted from 1 April 1969 to 31 March 1970 and continued the tagging and exploratory programs and expanded the survey of biological data (length, weight, fecundity, food habits). The third and final segment, conducted from 2 June 1970 to 31 August 1971, continued all the above and expanded the exploratory program offshore to monitor the possible effects of foreign fishing on anadromous species. In addition, an estuarine program on anadromous species in Albemarle Sound and its tributaries was initiated during the third segment to determine if, in fact, any relationships existed between anadromous fishes caught in the ocean off North Carolina, and those caught in the North Carolina estuaries. All field work was terminated 30 June 1971. The estuarine program will be expanded in the future to complement a continuing effort offshore.

STUDY AREAS

Offshore Study Area

The coastal area of North Carolina and adjacent states was divided into four major sampling areas: Area I extended south from Cape Fear, Area II from Cape Fear to Cape Lookout, Area III from Cape Lookout to Cape Hatteras, Area IV from Cape Hatteras northward. Sampling was conducted from just outside the surf zone to depths of 300 fathoms (Figures 2 and 3).

Inshore Study Area

The inshore study area is shown in Figure 4. Albemarle Sound is approximately 60 miles long (east-west), up to 15 miles wide (north-south), and about 500 square miles in area. The eastern end of the sound is slightly brackish with salinities up to 1.8 parts per thousand recorded. The western portion of the Albemarle Sound is essentially fresh water. Maximum depth of the sound is about 25 feet.

Alligator and Scuppernong Rivers enter Albemarle Sound from the south. Both are typical black water streams draining large swamp area. Roanoke River, which enters the western end of Albemarle Sound, is one of North Carolina's largest rivers. Its headwaters lie in the upper Piedmont. It flows along much of the Virginia/North Carolina border before turning south to Albemarle Sound. The lower reaches of the river drain extensive swamps. Chowan River also enters the western end of Albemarle Sound. It originates near the Virginia border and flows south through extensive swamps before entering the sound. Perquimans, Little, Pasquotank, and North Rivers are all relative short, wide rivers which drain large swampy areas before entering Albemarle Sound from the north.

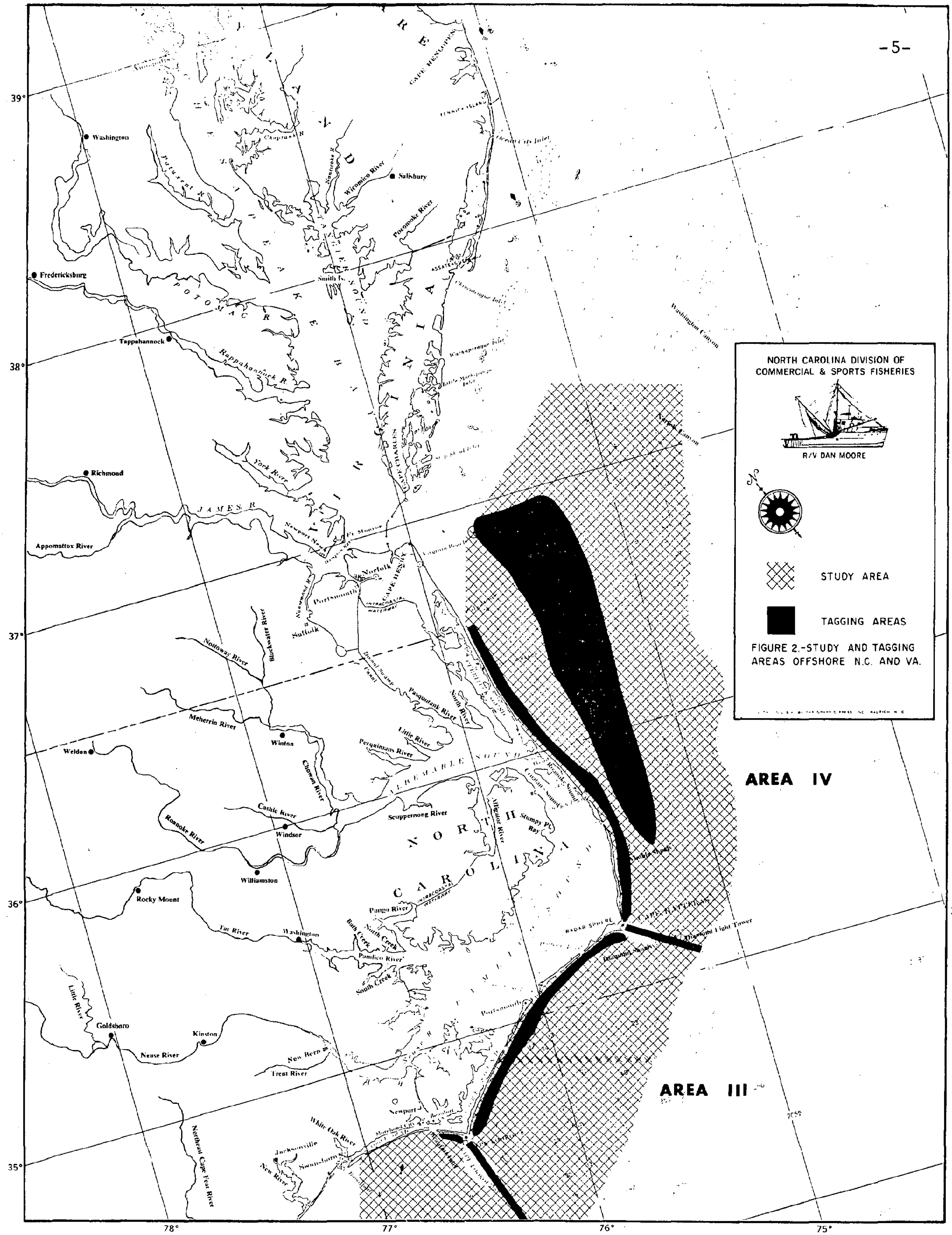


FIGURE 2.-STUDY AND TAGGING AREAS OFFSHORE N.C. AND VA.

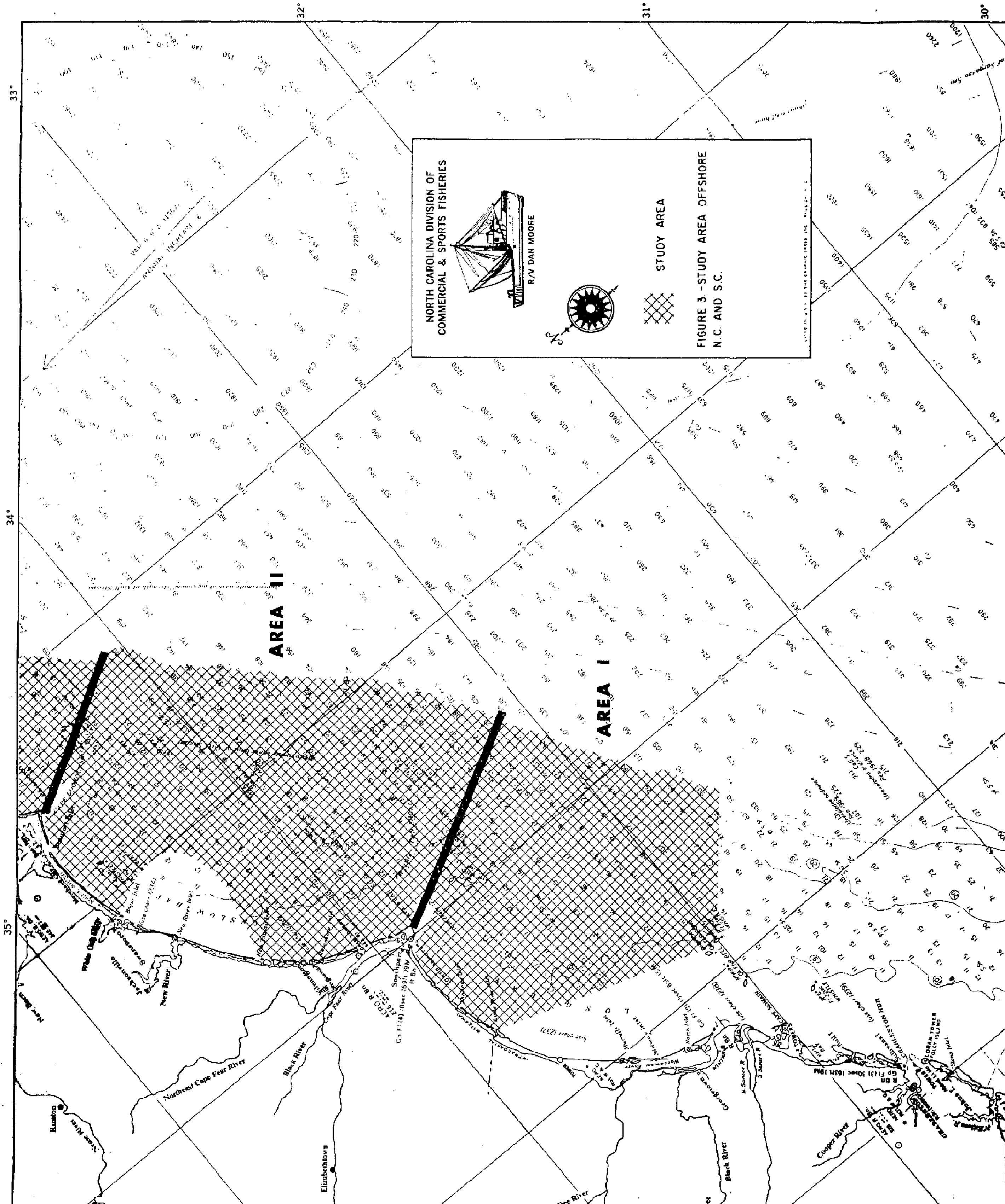


FIGURE 3.-STUDY AREA OFFSHORE N.C. AND S.C.

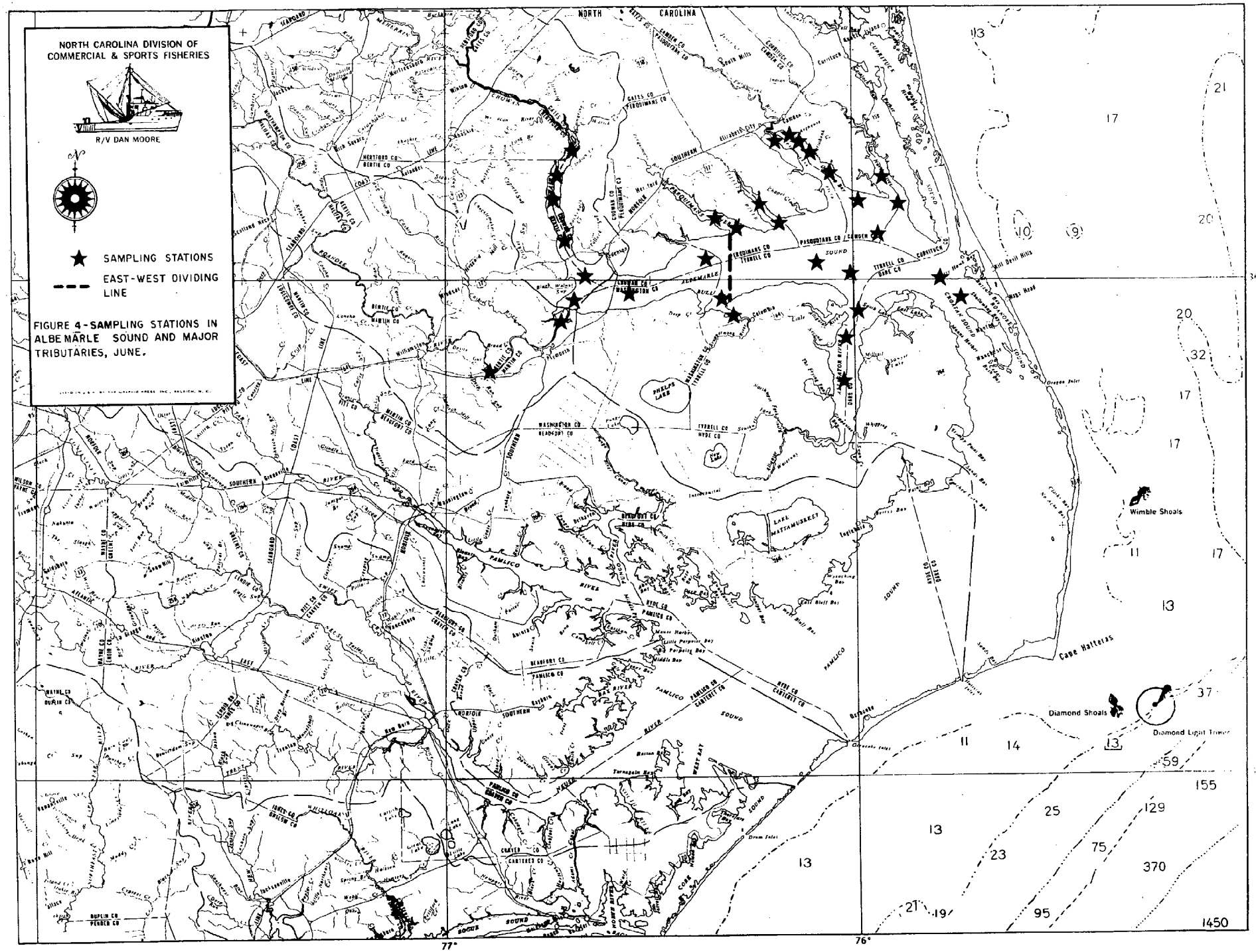


FIGURE 4 - SAMPLING STATIONS IN ALBEMARLE SOUND AND MAJOR TRIBUTARIES, JUNE.

METHODS AND PROCEDURES

Offshore Sampling Methods

During the first segment (1968-1969 season), several types of sampling gear were employed: a 68-ft. double-rigged shrimp trawl and a #41 Yankee trawl with a 72-ft. headrope and a 90-ft. sweep (Figure 5). Other gears employed to supplement the trawl data were ocean gill nets approximately 240 yards long which were fished vertically from the surface to depths of 60 fathoms. The net panels were composed of mesh sizes ranging from 2 3/4 inches to 9 inches stretched mesh. The nets, totalling approximately 1 1/2 miles in length, were set and retrieved from hydraulically operated seine drums aboard the R/V Dan Moore. All gears were eventually discontinued, however, during the first segment except the #41 Yankee trawl which proved to be the most effective for capturing anadromous fish. It was utilized throughout the two succeeding segments. During the second segment (1969-1970 season), a midwater trawl (Figure 6), with a 53-ft. headrope that opened 33-ft., was obtained late in the study period and fished experimentally during March 1970. During the third or final segment (1970-1971 season), a #36 Yankee trawl (same as #41 Yankee trawl but having a 62-ft. headrope and an 80-ft. sweep), an Irish 3-bridle trawl (Figure 7) with a 148-ft. headrope and a 178-ft. sweep, and the midwater trawl mentioned above, were utilized in addition to the #41 Yankee trawl. Bracket doors (8 1/2 x 4 1/3 ft.) and ground cable of various lengths were used in conjunction with all trawls except the midwater trawl. Steel suberkrub doors (8 x 3 1/2 ft.) were used in conjunction with the midwater trawl. The #36 and #41 Yankee trawls were most effective in the inshore (3-10 fathoms) and midshore 11-20 fathoms) zones. The midwater trawl was most effective in the midshore and offshore (21 to 300 fathoms) zones and the Irish 3-bridle trawl was effective in all three zones.

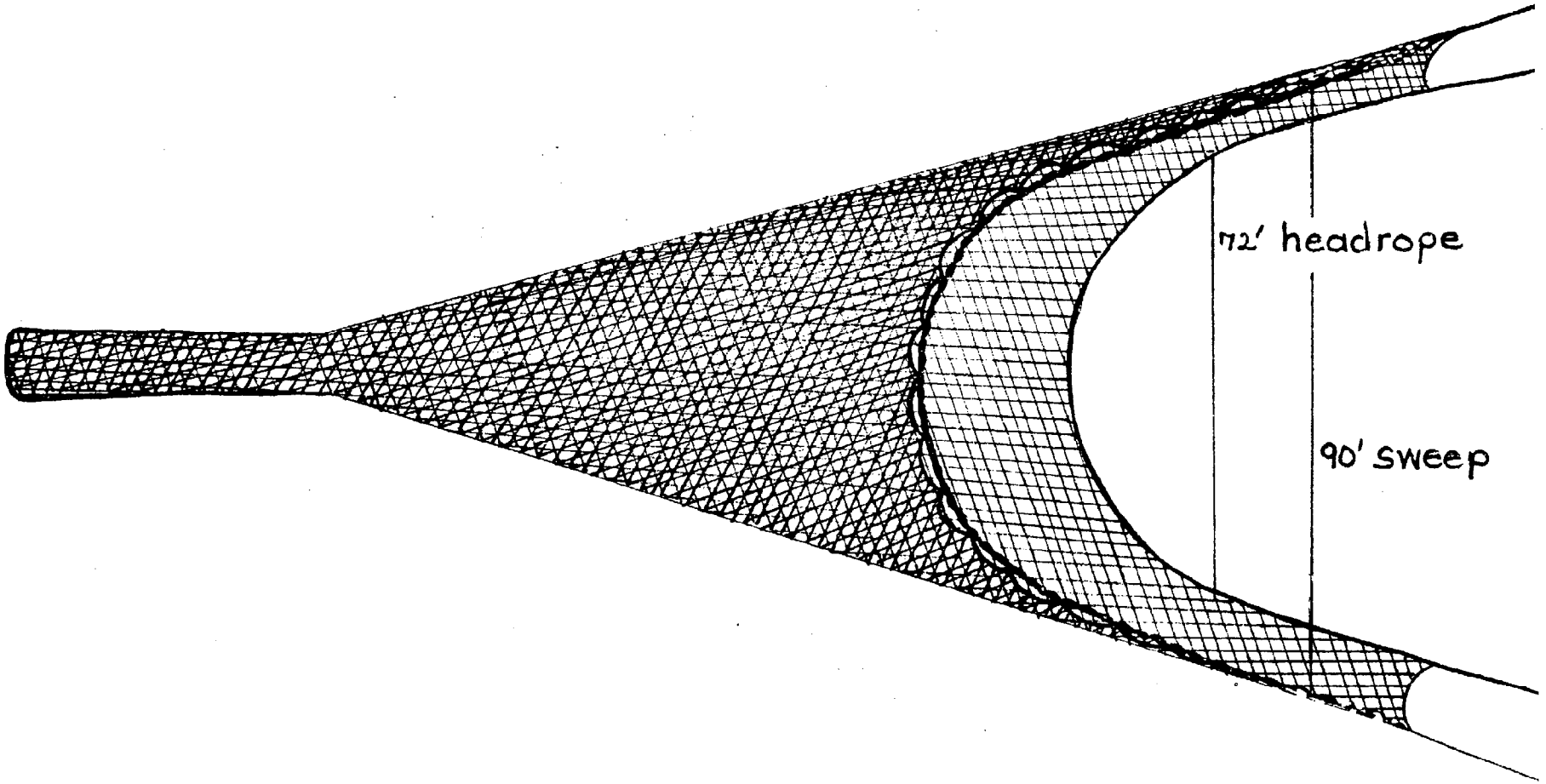


Figure 5.—#41 Yankee trawl (bottom view).

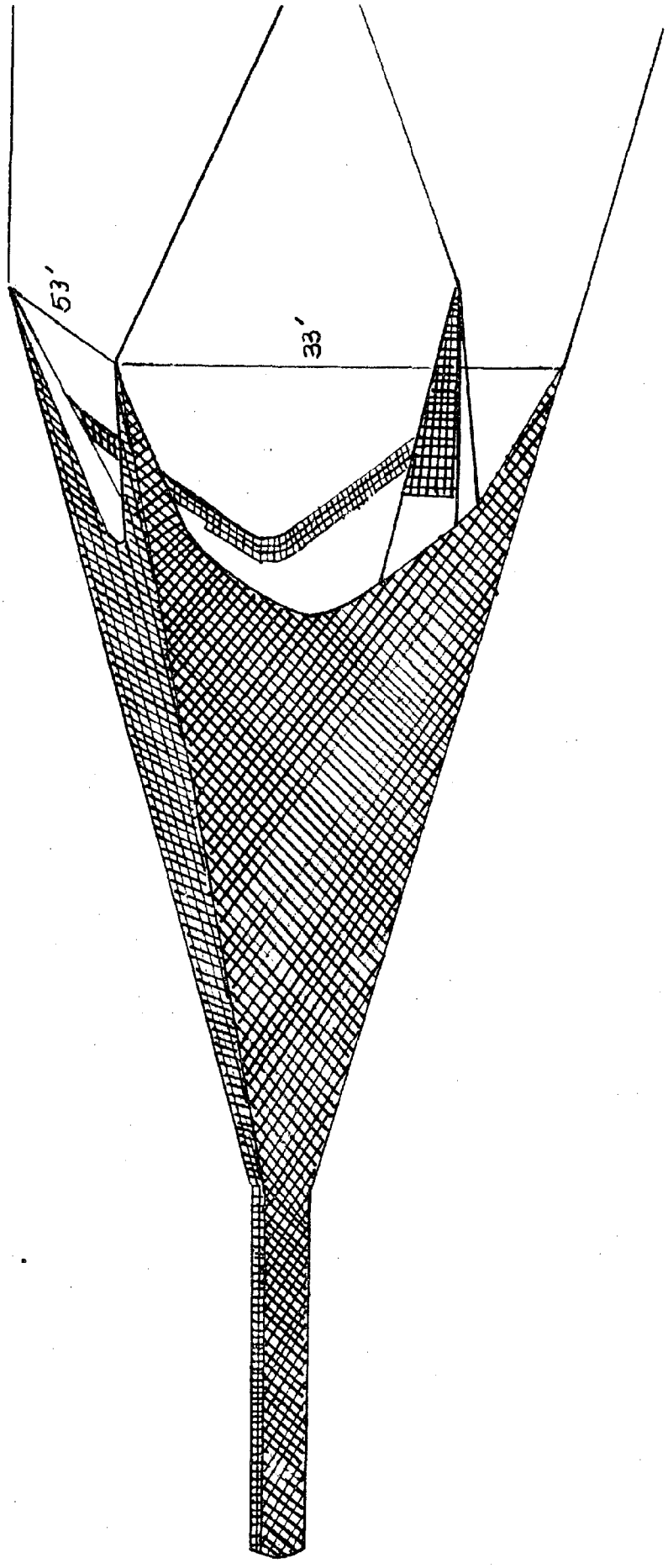


Figure 6.--Midwater trawl (side view).

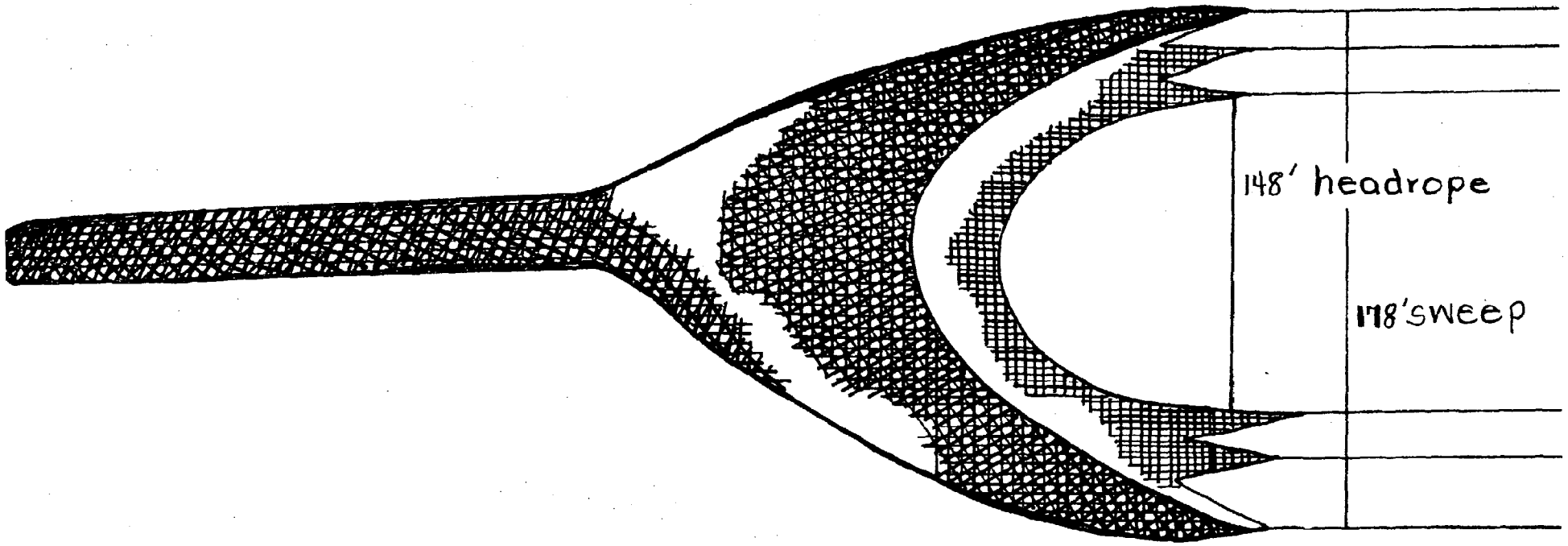


Figure 7.—Irish 3-bridle trawl (bottom view).

In an attempt to locate offshore concentrations of anadromous fishes and to increase chances of locating foreign fishing activity, transects were conducted every 20 minutes of latitude, from 2 to 100 fathoms offshore, from just north of Cape Charles, Virginia to Cape Romain, South Carolina. These transects were conducted, during both day and night hours, on a round-the-clock basis. Electronic fish detecting equipment was monitored continually during and between sample stations.

Tows varied from 5 to 120 minutes although most tows were 30 minutes or less. The longer tows were usually of an exploratory nature, in areas where anadromous species were not previously known. Most of the shorter tows (usually 10 or 15 minutes) were made in areas of known concentrations of anadromous fishes to capture healthy fishes for tagging.

Captured fish were placed in 350-gallon fiberglass tanks supplied with running seawater. Fish too small or too weak for tagging were either frozen or preserved in 10 percent formalin for later study.

Anadromous fishes in random samples were sexed, measured, weighed and aged from scale samples. These data were used to determine sex ratio, length-frequency distribution, length-weight relationships and age composition.

Inshore Sampling Methods

Trawling was conducted from the Division of Commercial and Sports Fisheries vessel Cape Fear (June), using a 25-ft. two-seam shrimp trawl, an experimental three-bridle trawl with a 32-ft. headrope, a 24-ft. crab trawl, and a 5-ft. plankton net with 1 mm mesh. The three-bridle net was used simultaneously with the shrimp trawl in Pasquotank River (3 samples) and Little River (1 sample). The plankton net was used to check for larval fish between Plymouth and the mouth of the Roanoke River. Towing time for all gear ranged from 5 to 30 minutes.

Samples of alewife and blueback herring collected from 1 March 1971 through 4 May 1971 at Tunis, on Chowan River, were taken from unculled catches from a series of seven pound-nets operated by local fishermen. These fishes were measured, weighed, aged, and sexed to determine if, in fact, a relationship exists between fishes caught in the ocean off North Carolina and those caught in the Chowan River.

Tagging Methods

Only captured anadromous fishes which appeared vigorous after spending several minutes in holding tanks were tagged. Striped bass and sturgeon were tagged with FT-1 Floy dart tags, while all other anadromous species were tagged with Floy FT-2 dart tags and FD-67 anchor tags. The station number, location, date, tag number, length, and weight were recorded for all tagged specimens prior to their release.

Rewards of from $1.00 to $25.00 were offered for the return of tags and information concerning the capture of tagged fish. Posters describing the tagging program were distributed along the Atlantic coast, and articles were submitted to various newspapers to further publicize the program. The monthly "Tar Heel Coast", a Division newsletter, also featured information concerning the tagging program, placing particular emphasis on mentioning the names of persons who returned tags.

Food Habit Analysis

Efforts were made offshore to obtain stomachs of striped bass, American shad, hickory shad, blueback herring, and alewife.

During the first segment of the study, stomach contents of 50 striped bass, most of them under 2.3 kilograms in weight, were examined. During the second segment, contents of 50 striped bass stomachs (all but two from fish weighing more than 2.3 kilograms) and 19 American shad stomachs (4 adults and 15 juveniles) were examined. During the final segment, 52 striped bass stomachs (all but six from fish weighing more than 2.3 kilograms) and 41 adult American shad, 16 blueback herring, and 11 alewife stomachs were examined. During the three-year study, 48 adult Hickory shad were captured, tagged and released.

During the first and second segments, stomachs were wrapped in cheese cloth, labeled, and placed in gallon jars containing 10 percent formalin. The stomach contents were examined and identified in the laboratory. During the second segment, food organisms were recorded by frequency of occurrence, weight, and volume. During the third segment, stomachs were not preserved and the contents were examined and identified while still fresh in order to make identifications of smaller invertebrates and fishes which might have been present, but might have deteriorated even after being preserved.

Fecundity

From offshore North Carolina, 35 female striped bass, ranging from 5.4 to 19.0 kilograms, and 43 female American shad, ranging from 1.0 to 2.3 kilograms, were selected for fecundity analysis. Ovaries from alewife and blueback herring were taken during February and March of 1971, but ova proved too immature to accurately estimate fecundity.

The fish were weighed and measured prior to removal of the ovaries. Scale samples were taken for age determination. The ovaries were wrapped in cheese cloth, labeled, and fixed in 10 percent formalin prior to ova counting.

In the laboratory, the ovaries were patted as dry as possible with paper towels and weighed to the nearest .01 gram. Fecundity of striped bass was

determined by procedures similar to those of Jackson and Tiller (1952). Fecundity of American shad was determined by procedures similar to those of Lehman (1953) as modified by Davis (1957). A one-gram sample, including some membrane, was removed from the center portion of each of the two ovaries and an actual total ova count for each one-gram sample was taken. Each sample was placed in a small Syracuse watch glass, teased apart, and counted under a dissecting microscope. Mature ova were differentiated from anlagen on the basis of size and appearance (Jackson and Tiller, 1952; Merriman, 1941; Lehman, 1953).

Total estimated fecundity was computed by calculating the number of ova per gram for each ovary, then multiplying that value by the weight of the respective ovaries. The estimated fecundities of the right and left ovaries were then added to obtain the total estimated fecundity.

RESULTS AND DISCUSSION

Sampling

During the field activities of the project study period (1 February 1968 through 30 June 1971), 1,038 trawl stations and 10 ocean gill net stations were taken from near Cape Romain, South Carolina, to a few miles north of Cape Charles, Virginia (Figures 2 and 3). All successful stations during the first and second segments were taken with a #41 Yankee trawl except six stations in March 1970, sampled with an experimental midwater trawl. During the third segment, all successful stations sampled with a #41 or #36 Yankee trawl were from 3 to 20 fathoms, with a midwater trawl from 21 to 300 fathoms, and with an Irish 3-bridle trawl from 3 to 100 fathoms. Along with the seven species of anadromous fish, large concentrations of other species were found in the study area. The following were numerous in samples over 80 fathoms in depth: Smooth dogfish (Mustelus canis), spiny dogfish (Squalus acanthias), silver hake (Merluccius bilinearis), goosefish (Lophius americanus), four-spot flounder (Paralichthys oblongus), and butterfish (Peprilus triacanthus).

Concentrations of planehead filefish (Monacanthus hispidus), scup (Stenotomus chrysops), northern searobin (Prionotus carolinus), Atlantic mackerel (Scomber scombrus), and round herring (Etrumeus teres) were found in the mid-depths, 20 to 80 fathoms. Samples taken from the surf zone out to 20 fathoms resulted in large catches of spiny dogfish, bluefish (Pomatomus saltatrix), summer flounder (Parlichthys dentatus), butterfish, orange filefish (Aluterus schoepfi), striped anchovy (Anchoa hepsetus), Atlantic herring (Clupea harengus harengus), goosefish and various Sciaenidae, chiefly spotted sea trout (Cynoscion nebulosus), weakfish (Cynoscion regalis), spot (Leiostomus xanthurus), Atlantic croaker (Micropogon undulatus), silver perch (Bairdiella chrysura), and red drum (Sciaenops ocellata).

During the first segment of the study, 3,661 adult anadromous fishes and 472 juveniles were captured in 222 trawl samples. Only 8 adult American shad,

8 shortnose sturgeon, and 5 Atlantic sturgeon were taken. An additional 66 juvenile American shad were included in the catches. Catches of striped bass totalled 1,180 fish. Blueback herring catches contained 649 adults and 352 juveniles. Also included were 1,808 adult and 54 juvenile alewife. Only three adult hickory shad were caught.

Overall catches of anadromous fishes were considerably less during the second segment. A probable explanation is that sampling during the second segment was spread over a larger area in an attempt to learn more about the distribution of anadromous species.

During the second segment, 984 anadromous fishes were captured in 459 trawl samples: 467 striped bass, 37 American shad (11 adults and 26 juveniles), 2 hickory shad, 238 blueback herring (197 adults and 41 juveniles), 148 alewife (29 adults and 119 juveniles), 91 Atlantic sturgeon, and 1 shortnose sturgeon.

During the third segment, 4,617 anadromous fishes were captured in 357 trawl samples: 894 striped bass, 355 American shad, 1 shortnose sturgeon, 94 Atlantic sturgeon, 2,865 blueback herring, 365 alewife, and 43 hickory shad.

Coastal Distribution

As indicated by data in Tables 1, 2 and 3, and Figure 2, anadromous species appear to be concentrated in Areas III and IV. No anadromous fishes were taken in Area I. Except for one small Atlantic sturgeon captured near Wrightsville Beach (about 25 miles north of Cape Fear), all anadromous fishes taken in Area II came from Bogue Inlet east to Cape Lookout. Only small catches of Atlantic sturgeon (3), shortnose sturgeon (5), blueback herring (20), and hickory shad (1) were taken in this area. Although sampling indicated few anadromous fishes were present in Area II, occasional commercial catches of anadromous species, principally Atlantic sturgeon, have been made in the area. In April, 1968, 64,000 pounds of Atlantic sturgeon were taken in gill nets fished near Bogue Inlet.*

*unpublished data from Ntl. Mar. Fish. Ser., Br. of Statistics, Beaufort, N.C.

Table 1.--Relative abundance of offshore anadromous fishes of North Carolina by sampling area (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fish) 1968 - 1969

Species	AREA I 24 samples			AREA II 27 samples			AREA III 49 samples			AREA IV 122 samples			TOTAL 222 samples		
	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish
Striped bass (Morone saxatilis)	0	0	0	0	0	0	2	*	4.1	1178	9.7	36.1	1180	5.3	20.7
American shad (Alosa sapidissima)	0	0	0	0	0	0	2	*	2.0	6	*	3.3	8	*	2.2
Shortnose sturgeon (Acipenser brevirostrum)	0	0	0	5	0.2	3.7	1	*	2.0	2	*	1.6	8	*	1.8
Atlantic sturgeon (Acipenser oxyrhynchus)	0	0	0	0	0	0	0	0	0	5	*	2.4	5	*	1.4
Blueback herring (Alosa aestivalis)	0	0	0	0	0	0	2	*	4.1	647	5.3	7.4	649	2.9	5.0
Alewife (Alosa pseudoharengus)	0	0	0	0	0	0	0	0	0	1808	14.8	34.4	1808	8.1	18.9
Hickory shad (Alosa mediocris)	0	0	0	0	0	0	1	*	2.0	2	*	0.8	3	*	0.9
	0			5			8			3648			3661		

* less than 0.1 fish/sample

Table 2.—Relative abundance of offshore anadromous fishes of North Carolina by sampling area (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fish) 1969 - 1970

Species	AREA I (23 samples)			AREA II (67 samples)			AREA III (191 samples)			AREA IV (178 samples)			TOTAL (459 samples)		
	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish
Striped bass (Morone saxatilis)	0	0	0	0	0	0	259	1.4	22.5	208	1.2	13.5	467	1.1	15.7
American shad (Alosa sapidissima)	0	0	0	0	0	0	5	*	1.0	32	0.2	5.5	37	*	2.8
Shortnose sturgeon (Acipenser brevirostrum)	0	0	0	0	0	0	1	*	0.5	0	0	0	1	*	0.2
Atlantic sturgeon (Acipenser oxyrhynchus)	0	0	0	3	*	4.5	84	0.4	20.0	4	*	2.0	91	0.2	10.0
Blueback herring (Alosa aestivalis)	0	0	0	13	0.2	9.0	27	0.1	8.5	198	1.1	4.5	238	0.5	6.9
Alewife (Alosa pseudoharengus)	0	0	0	0	0	0	27	0.1	5.5	121	0.7	10.5	148	0.3	6.9
Hickory shad (Alosa mediocris)	0	0	0	1	*	1.5	1	*	0.5	0	0	0	2	*	0.4
				17			404			563			984		

* less than 0.1 fish/sample

Table 3.--Relative abundance of offshore anadromous fishes of North Carolina by sampling area (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fish) 1970 - 1971

Species	AREA I 11 samples			AREA II 59 samples			AREA III 77 samples			AREA IV 210 samples			TOTAL 357 samples		
	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish	Tot. catch (no.)	Avg. no.	Pct. with fish
Striped bass (Morone saxatilis)	0	0	0	0	0	0	62	0.8	11.7	832	4.0	44.7	894	2.5	28.3
American shad (Alosa sapidissima)	0	0	0	0	0	0	1	*	1.3	354	1.7	6.2	355	1.0	3.9
Shortnose sturgeon (Acipenser brevirostrum)	0	0	0	0	0	0	0	0	0	1	*	0.5	1	*	0.3
Atlantic sturgeon (Acipenser oxyrhynchus)	0	0	0	0	0	0	10	0.1	10.4	84	0.4	16.7	94	0.3	12.0
Blueback herring (Alosa aestivalis)	0	0	0	7	0.1	8.4	2258	29.3	13.0	600	2.9	13.3	2865	8.0	12.0
Alewife (Alosa pseudoharengus)	0	0	0	0	0	0	150	1.9	1.3	215	1.0	12.4	365	1.0	7.6
Hickory shad (Alosa mediocris)	0	0	0	0	0	0	1	*	1.3	42	0.2	4.3	43	0.1	2.8
				7			2482			2128			4617		

* less than 0.1 fish/sample

Approximately 99.6 percent of the anadromous fishes collected during the three-year study were taken in Area III (31.2%) and Area IV (68.4%). Several contrasts may be noted between the results obtained from these areas during the first (1968-1969 segment), second (1969-1970 segment), and third (1970-1971 segment). During the first segment, 99 percent of the anadromous catch came from Area IV, during the second segment 57.2 percent, and during the third segment 46.1 percent. However, less than one percent of the 1968-1969, 41 percent of the 1969-1970, and 53.8 percent of the 1970-1971 catch came from Area III.

Striped Bass

During the 1969-1970 segment more than 55.5 percent of the striped bass captured came from Area III. Striped bass were found along the beach throughout the entire area from Cape Lookout to Cape Hatteras. The greatest concentration was found off Portsmouth Island (south side of Ocracoke Inlet) where 179 striped bass were captured. Only two striped bass were captured in all of Area III during 1968-1969 and 62 (7%) during the 1970-1971 segment. During the first segment 99 percent, and the third segment 93 percent, of the striped bass captured came from Area IV. The catches were distributed from Cape Hatteras to False Cape with the largest concentrations coming from False Cape, Currituck beach, Oregon Inlet, and Chicamacomico.

Atlantic Sturgeon

Almost 93 percent of the total Atlantic sturgeon catch during the second segment and 11 percent during the third segment came from Area III. The remaining 89 percent of the Atlantic sturgeon during the third segment, and all the Atlantic sturgeon during the first segment, were caught in Area IV. The other Atlantic sturgeon taken during the second segment were caught in Area II (3%) and Area IV (4%). All the fish caught in Areas III and IV were evenly distributed along the beach.

Alewife and Blueback Herring

During the first segment, two blueback herring and no alewife were caught in Area III. During the second segment 27 blueback and 27 alewife were caught in Area III. However, during the third segment, 2,258 (79%) of the blueback herring, and 150 (41%) of the alewife were captured in Area III.

In the first segment, 647 (99%) of the bluebacks, and 1,808 (100%) of the alewife were captured in Area IV. In the second segment, 198 (84%) of the blueback herring and 121 (82%) of the alewife were captured in Area IV. (In the second and third segment, 5% and 0.2% of the blueback herring, respectively, were captured in Area II). However, only 600 (21%) and 215 (59%) of the blueback herring and alewife, respectively, were caught in Area IV during the third segment study.

Most of the blueback herring and alewife taken in Area III during the first and second segments were captured from Cape Hatteras Bight to Hatteras Inlet. During the 1970-1971 study, the 2,258 blueback herring and 150 alewife were caught in two tows in Hatteras Bight. During the first two segments blueback herring were also caught off Core Banks 5-15 nautical miles north of Cape Lookout.

In Area IV, the herring were caught from Wimble Shoals to Cape Henry with the majority caught amid foreign fishing fleets 15-30 miles east of Currituck Beach.

American Shad

During the third segment (1970-1971), catches of American shad were essentially in Area IV, as 346 of the total 355 were caught at Oregon Inlet.

Catches of clupeids were inconsistent (2,258 blueback herring in two tows in 1971, 346 American shad in two tows in 1971, and 1,808 alewife in ten tows in 1969). The probable reason for the inconsistency in catches was the schools were not evently distributed where fishing effort was applied.

Depth Distribution

The study area was divided into three depth zones: inshore (0-10 fathoms), midshore (11-20 fathoms), and offshore (21-300 fathoms). Depth distribution data collected during each year of the study agreed closely. Approximately 94 percent of the anadromous fishes taken during the three-year study were collected from the inshore zone (Tables 4, 5 and 6).

Striped bass were found exclusively in the inshore zone. Only one hickory shad and one Atlantic sturgeon were found outside the inshore zone and both were captured in the midshore zone during the first segment of the study.

Approximately 97 percent (390) of the American shad captured were found in the inshore zone, with 353 captured at Oregon Inlet during the third segment. Only three were found in the midshore zone and seven in the offshore zone.

Almost 87 percent (3,252) of the blueback herring captured were found in the inshore zone. Approximately 13 percent (496) were captured in the midshore zone during the third segment 15 miles east of Currituck Light, North Carolina among the East German fleet. Only two had been captured previously in the midshore zone, and these were taken during the second segment in 13 fathoms of water off Wimble Shoals, North Carolina.

Approximately 98 percent (2,271) of the alewife captured were found in the inshore zone. Almost 80 percent of these were captured during the first segment as far south as Wimble Shoals and north to the mouth of the Chesapeake Bay. Forty-nine were captured in the midshore zone, during the third segment 15 miles east of Currituck Light among the East German fleet. One was also captured in the offshore zone during the second segment.

During the second segment, the few American shad, blueback herring and alewife captured in the offshore zone were taken at depths of 83 to 129 fathoms off the mouth of Chesapeake Bay (Area IV). Encountering these species at similar depths has been noted before (Netzel and Stanek, 1966), but not as far

Table 4.--Relative abundance and depth distribution of offshore anadromous fishes of North Carolina (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fish) 1968 - 1969

Species	INSHORE (172 samples) 0 - 10 fm			MID-SHORE (30 samples) 11 - 20 fm.			OFFSHORE (16 samples 21 - 300 fm.		
	Total catch	Avg. catch	Pct. with fish	Total catch	Avg. catch	Pct. with fish	Total catch	Avg. catch	Pct. with fish
Striped bass (Morone saxatilis)	1180	6.9	27.3	0	0	0	0	0	0
American shad (Alosa sapidissima)	5	*	1.8	1	*	3.2	2	0.1	0.3
Shortnose sturgeon (Acipenser brevirostrum)	8	*	2.3	0	0	0	0	0	0
Atlantic sturgeon (Acipenser oxyrhynchus)	4	*	1.8	1	*	3.2	0	0	0
Blueback herring (Alosa aestivalis)	649	3.8	6.2	0	0	0	0	0	0
Alewife (Alosa pseudoharengus)	1808	10.5	24.5	0	0	0	0	0	0
Hickory shad (Alosa mediocris)	2	*	0.4	1	*	2.2	0	0	0
	3656			3			2		

* less than 0.1 fish/sample

Table 5.--Relative abundance and depth distribution of offshore anadromous fishes of North Carolina (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fish) 1969 - 1970

Species	INSHORE (236 samples) 0 - 10 fm.			MID-SHORE (70 samples) 11 - 20 fm.			OFFSHORE (153 samples 21 - 300 fm.		
	Total catch	Avg. catch	Pct. with fish	Total catch	Avg. catch	Pct. with fish	Total catch	Avg. catch	Pct. with fish
Striped bass (Morone saxatilis)	467	2.0	30.5	0	0	0	0	0	0
American shad (Alosa sapidissima)	32	0.1	0.4	0	0	0	5	0.3	2.6
Shortnose sturgeon (Acipenser brevirostrum)	1	*	0.4	0	0	0	0	0	0
Atlantic sturgeon (Acipenser oxyrhynchus)	91	0.4	18.6	0	0	0	0	0	0
Blueback herring (Alosa aestivalis)	232	1.0	9.8	2	0.3	1.4	4	0.3	1.3
Alewife (Alosa pseudoharengus)	147	0.6	13.1	0	0	0	1	*	0.6
Hickory shad (Alosa mediocris)	2	*	0.8	0	0	0	0	0	0
	972			2			10		

* less than 0.1 fish/sample

Table 6.--Relative abundance and depth distribution of offshore anadromous fishes of North Carolina (as indicated by total catch, average catch per sample, and percent of samples taking offshore anadromous fish) 1970 - 1971

Species	INSHORE (332 samples) 0 - 10 fm. Total catch	Avg. catch	Pct. with fish	MID-SHORE (17 samples) 11 - 20 fm. Total catch	Avg. catch	Pct. with fish	OFFSHORE (8 samples) 21 - 300 fm. Total catch	Avg. catch	Pct. with fish
Striped bass (Morone saxatilis)	894	2.7	31.0	0	0	0	0	0	0
American shad (Alosa sapidissima)	353	1.1	3.9	2	0.1	5.9	0	0	0
Shortnose sturgeon (Acipenser brevirostrum)	1	*	0.3	0	0	0	0	0	0
Atlantic sturgeon (Acipenser oxyrhynchus)	94	0.3	13.0	0	0	0	0	0	0
Blueback herring (Alosa aestivalis)	2371	7.1	10.8	494	29.1	41.2	0	0	0
Alewife (Alosa pseudoharengus)	316	0.9	6.6	49	2.9	29.4	0	0	0
Hickory shad (Alosa mediocris)	43	0.1	3.0	0	0	0	0	0	0
	4072			543					

* less than 0.1 fish/sample

south. The collection of these fish in the offshore area probably has little commercial significance since so few were found; however, it does provide some information as to where these species might be found between spawning migrations.

Seasonal Distribution

Sampling was conducted from December 1968 to March 1969 during the first segment, in April 1969 and from August 1969 to March 1970 during the second segment, and in June 1970 and from October 1970 to June 1971 during the third segment (Tables 7, 8, and 9).

Anadromous fishes were collected in December 1968 and January through March 1969 during the first segment, in April 1969 and November 1969 through March 1970, during the second segment, and October 1970 through April 1971 and again in June 1971 during the third segment (Tables 7, 8, and 9).

Sufficient quantities of five of the seven species were taken to indicate seasonal abundance (Tables 8 and 9). Approximately 99 percent of the total anadromous fishes collected during the second and third segments were taken from November through March, with 65 percent of the total taken during March alone. This information is not available from Sterling and Godwin (1970) for the initial segment.

Striped Bass

Striped bass were present in North Carolina sounds, particularly Albemarle Sound, throughout the year (North Carolina Landings, 1960-1971).* However, the occurrence of striped bass in the ocean appears to be of a seasonal nature. Collections made during the periods outlined in Tables 7, 8, and 9 resulted in striped bass taken as early as mid-November 1971 and through March of all three segments.

*Published and unpublished data from National Marine Fisheries Service, Branch of Statistics, Beaufort, N.C.

Table 7.--Seasonal distribution and percent of samples taking fish from offshore anadromous fish stocks, North Carolina, 1968 - 1969*

Species	December (18 samples)	January (35 samples)	February (36 samples)	March (70 samples)
Striped bass (*Morone saxatilis*)	11.2	34.3	50.0	15.8
American shad (*Alosa sapidissima*)	0	0	2.9	4.4
Shortnose sturgeon (*Acipenser brevirostrum*)	11.2	2.9	2.9	0
Atlantic sturgeon (*Acipenser oxyrhynchus*)	5.6	0	0	0
Blueback herring (*Alosa aestivalis*)	0	0	5.7	1.5
Alewife (*Alosa pseudoharengus*)	0	2.9	36.2	33.0
Hickory shad (*Alosa mediocris*)	5.6	0	2.9	0

* From Sterling and Godwin (1970)

Table 8.--Number of anadromous fish captured and percent of samples taking anadromous fish by months, offshore North Carolina 1969 - 1970

Species	APRIL 76 samples		AUGUST 22 samples		SEPTEMBER 46 samples		OCTOBER 25 samples		NOVEMBER 30 samples	
	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent
Striped bass (Morone saxatilis)	0	0	0	0	0	0	0	0	0	0
American shad (Alosa sapidissima)	3	3.9	0	0	0	0	0	0	2	3.3
Shortnose sturgeon (Acipenser brevirostrum)	0	0	0	0	0	0	0	0	0	0
Atlantic sturgeon (Acipenser oxyrhynchus)	0	0	0	0	0	0	0	0	2	6.7
Blueback herring (Alosa aestivalis)	4	2.6	0	0	0	0	0	0	0	0
Alewife (Alosa pseudoharengus)	1	1.3	0	0	0	0	0	0	0	0
Hickory shad (Alosa mediocris)	0	0	0	0	0	0	0	0	0	0
	8								4	

Species	DECEMBER 30 samples		JANUARY 83 samples		FEBRUARY 94 samples		MARCH 53 samples	
	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent
Striped bass (Morone saxatilis)	153	43.3	55	22.7	217	40.4	42	5.7
American shad (Alosa sapidissima)	4	3.3	1	1.2	27	7.4	0	0
Shortnose sturgeon (Acipenser brevirostrum)	0	0	1	1.2	0	0	0	0
Atlantic sturgeon (Acipenser oxyrhynchus)	1	3.3	30	22.9	48	18.1	10	13.2
Blueback herring (Alosa aestivalis)	1	3.3	3	3.6	33	19.2	197	15.1
Alewife (Alosa pseudoharengus)	1	3.3	9	7.2	136	24.5	1	1.9
Hickory shad (Alosa mediocris)	0	0	1	1.2	0	0	1	1.9
	160		100		461		251	

Table 9.--Number of anadromous fish captured and percent of samples taking anadromous fish by months, offshore North Carolina 1970 - 1971

Species	JUNE 16 samples		OCTOBER 44 samples		NOVEMBER 50 samples		DECEMBER 70 samples		JANUARY 54 samples	
	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent
Striped bass (Morone saxatilis)	0	0	0	0	104	42.0	517	54.3	122	24.1
American shad (Alosa sapidissima)	0	0	0	0	0	0	0	0	6	5.6
Shortnose sturgeon (Acipenser brevirostrum)	0	0	0	0	0	0	1	1.4	0	0
Atlantic sturgeon (Acipenser oxyrhynchus)	0	0	2	2.3	25	22.0	52	27.1	6	9.2
Blueback herring (Alosa aestivalis)	0	0	0	0	0	0	0	1.4	49	29.6
Alewife (Alosa pseudoharengus)	0	0	0	0	0	0	0	0	0	0
Hickory shad (Alosa mediocris)	0	0	0	0	3	6.0	0	0	16	9.2
			2		132		571		199	

Species	FEBRUARY 32 samples		MARCH 49 samples		APRIL 5 samples		MAY 7 samples		JUNE 30 samples	
	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent	Tot. fish	Per-cent
Striped bass (Morone saxatilis)	22	25.0	129	46.9	0	0	0	0	0	0
American shad (Alosa sapidissima)	3	6.2	346	18.4	0	0	0	0	0	0
Shortnose sturgeon (Acipenser brevirostrum)	0	0	0	0	0	0	0	0	0	0
Atlantic sturgeon (Acipenser oxyrhynchus)	2	6.2	7	10.2	0	0	0	0	0	0
Blueback herring (Alosa aestivalis)	256	3.1	2539	46.9	18	20.0	0	0	2	3.3
Alewife (Alosa pseudoharengus)	22	15.6	343	44.9	0	0	0	0	0	0
Hickory shad (Alosa mediocris)	0	0	24	4.1	0	0	0	0	0	0
	305		3388		18				2	

Atlantic Sturgeon

Atlantic sturgeon were taken during the first segment only in December. However, during the second and third segments, Atlantic sturgeon were captured as early as October of 1970 and from November through March of both segments. Atlantic sturgeon were most frequent in catches from November through February.

American Shad

During the second segment, five adult American shad were taken in deep water (83 to 105 fathoms) in April (3) and November (2). Inshore samples in December and January yielded five more adults. All except one of the American shad taken in February were juveniles spawned during the previous year. However, during the third segment, nine adults were captured during January and February and 346 adults were captured in March. From these data, it would appear that adult American shad were migrating to their fresh water spawning areas, not necessarily in North Carolina, as late as March 1971 during the third segment, and juveniles were emigrating from their nursery areas as late as February 1970 during the second segment.

Alewife

Alewife were taken from January 1969 through March 1969 during the first segment, in April 1969 and December 1969 through March 1970 during the second segment, and in February and March 1971 during the third segment. Juveniles, presumably leaving their inshore nursery areas, predominated in January and early February 1970, while adults were most frequent during the latter half of February and March 1969, 1970 and 1971.

Blueback Herring

Blueback herring were collected during the same months as alewife, and during the third segment juveniles (2) were captured in June. Adults predominated all of the blueback herring catches except in June, but were most dominant in March.

Growth and Size Relationships

Sufficient numbers of striped bass, Atlantic sturgeon, blueback herring, alewife and American shad were collected offshore North Carolina to determine length-weight, length-age, and length-frequency relationships. To complement the effort offshore, weekly sampling of alewife and blueback herring was conducted from 17 March through 4 May 1971 on Chowan River at Tunis. The Chowan River was selected because it apparently is the most economically important river in North Carolina with regard to alewife and blueback herring. Also, the river is a tributary to what is believed to be the most important nursery area for river herring in North Carolina, Albemarle Sound.

The exponential function $W = aL^b$, described and discussed by Beverton and Holt (1957) and used for expressing length-weight and length-age ($A = aL^b$) relationships, was used in this study. The linear regression equation $X = a+bX$ was used for expressing all linear relationships.

Length-frequency relationships were plotted for all the species using various size groups depending on the species maximum length. In addition, curvilinear (exponential) and linear fork length-weight, fork length-age, and fork length-total length (blueback herring only) regressions were calculated for the species when data were available. The curvilinear relationships gave the best fit except for the total length-fork length regression which was linear. All regressions presented in this section are either significant or highly significant at the 95 percent level of confidence.

Comparisons using correlation coefficients (r) were made between curvilinear regressions where mean values (e.g., average length of all 6-year old alewife) and data from individual fish were used in the calculations. The only cases where the curves differed substantially were in length-age regressions. The use of mean values gave a much more accurate curve when compared to plots of actual data. The fork length-age regressions using mean values are presented

in this section. Throughout this report, all weights are in kilograms (kg) or grams (g) while fork lengths were recorded in centimeters (cm) or millimeters (mm).

Striped Bass - Offshore

Weight (kg) and fork length (cm) were determined for 1,763 striped bass from February 1968 through June 1971. These fish ranged from 26 to 128 cm and from 0.45 to 26.3 kg. The length-weight relationship (336) and length-frequency distribution (1763) are presented in Figures 8 and 9, respectively. The length-frequency distribution indicated a peak of 35.0 to 39.9 cm in the 1968-1969 segment that was not reflected in the 1969-1970 or the 1970-1971 segments. Peaks of 45.0 to 49.9 and 60.0 to 64.9 cm in Area IV, and 90.0 to 94.9 cm in Area III are indicated for the 1969-1970 segment. The 90.0 to 94.9 cm group dominated the 1969-1970 segment. The winter haul seine and trawl fisheries on the Outer Banks fished both of the Area IV size groups, harvesting 154,000 pounds in December 1969 and 349,000 and 336,000 pounds, respectively, in January and February 1970.* No landings were reported during the same months on the large fish in Area III. The population of "Jumbo" striped bass in Area III appeared to be essentially unexploited during its stay off the North Carolina coast. While tag returns indicated a few of these fish were eventually caught by commercial fishermen during the spawning run in Chesapeake Bay, most of the harvest appeared to be by sports fishermen in the New England states.

Peaks of 55.0 to 54.9, 70.0 to 74.9, and 90.0 to 94.9 cm were evident during the 1970-1971 segment. While "Jumbo" stripers were present during 1970-1971, they were not as abundant as during the 1969-1970 segment. The 70.0 to 74.9 cm group dominated the 1970-1971 catch.

*Unpublished data from National Marine Fisheries Service, Branch of Statistics, Beaufort, N. C.

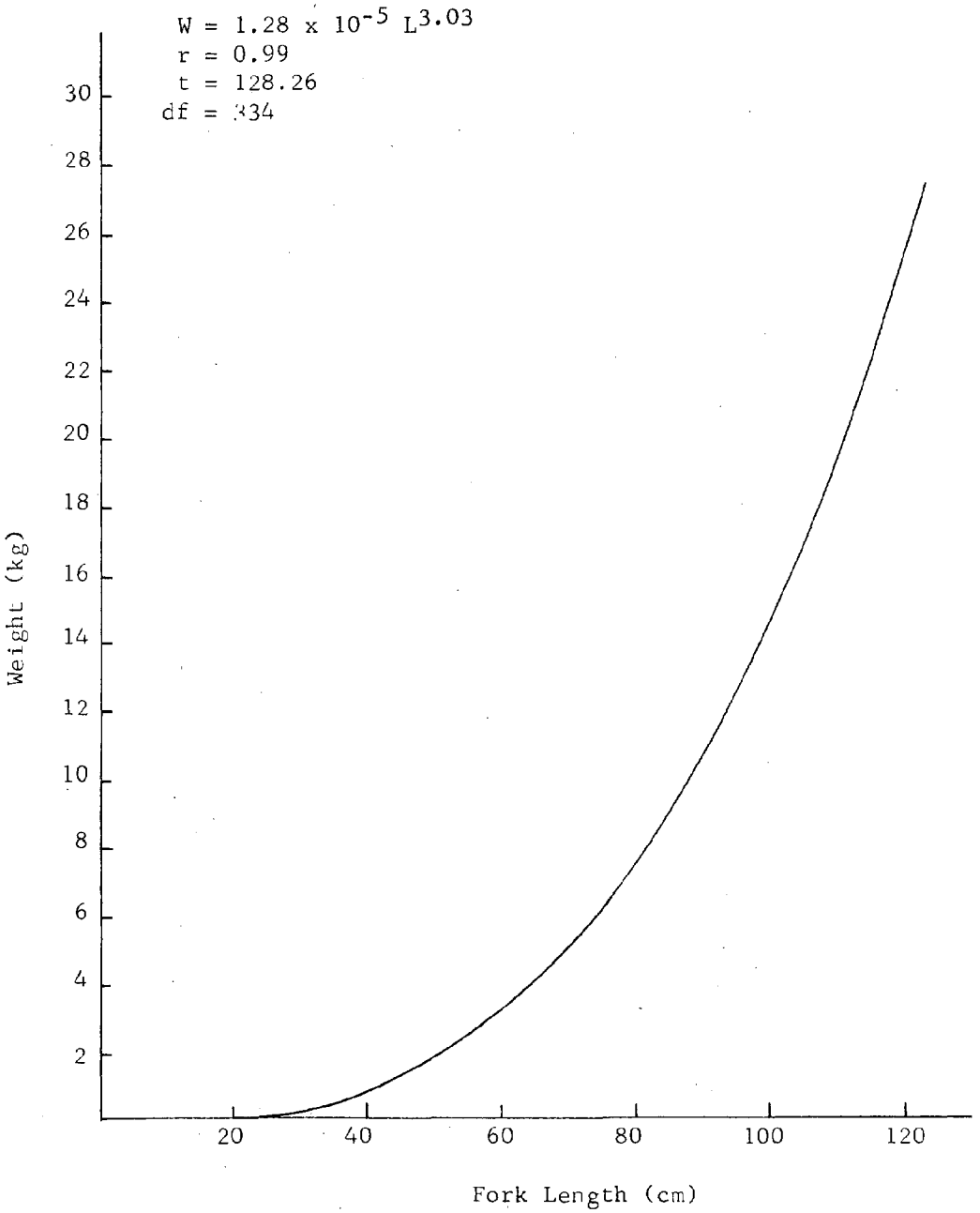


Figure 8.--Fork length-weight relationship for striped bass, offshore North Carolina, 1968 - 1971.

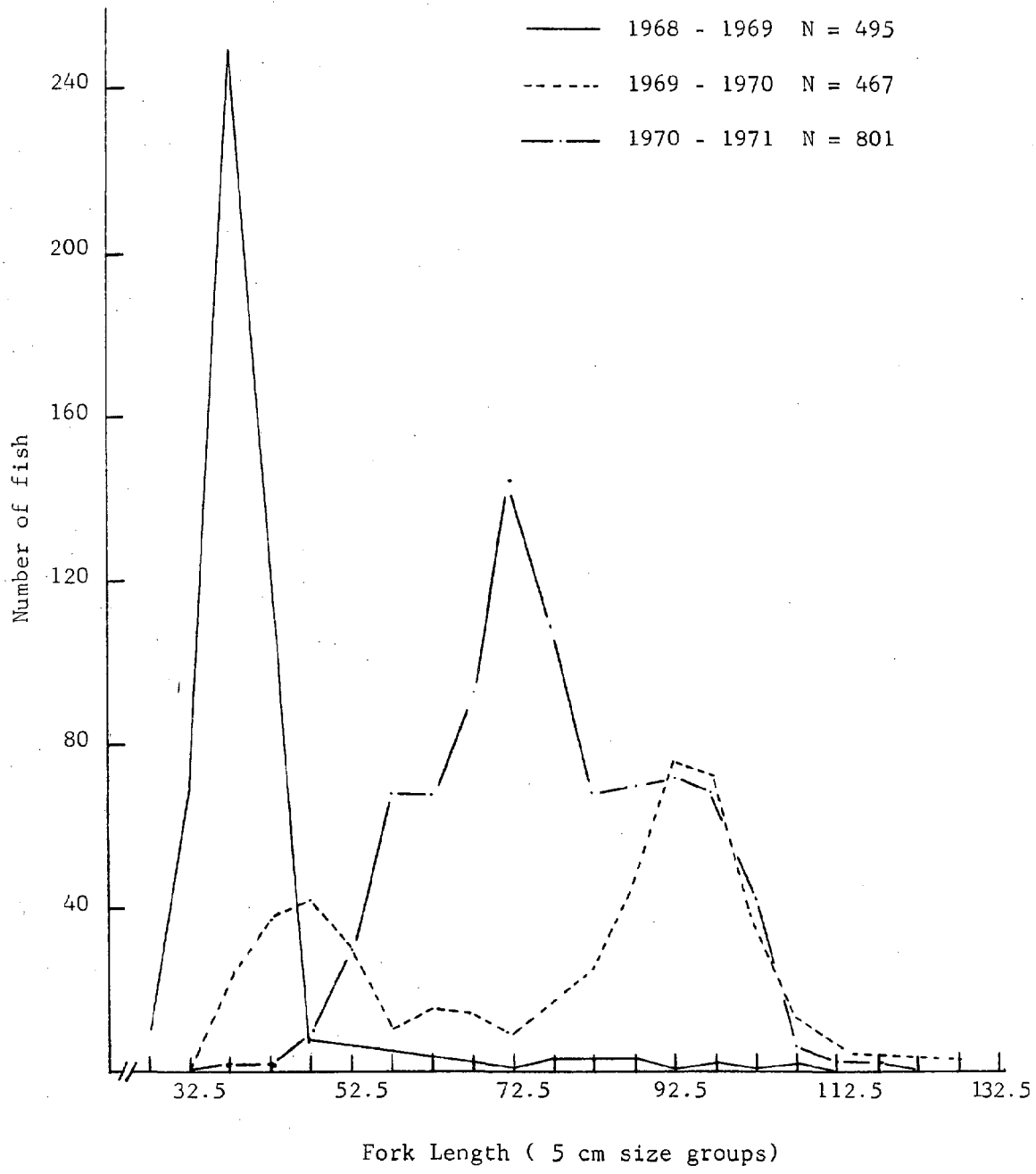


Figure 9.--Length-frequency distribution for striped bass, offshore North Carolina, 1968 - 1971.

A combined three-year sample of 290 striped bass (28.0 to 128.0 cm) was preserved for detailed biological analyses: length, weight, age, fecundity, and food habits. These fish ranged from two to fifteen years old. The fork length-age relationship data and regression for these 290 fish is presented in Table 10 and Figure 10, respectively. A plastic impression was made of scales from each fish and examined repeatedly by two, and sometimes three, individuals. Only scale samples on which agreement was obtained were used in age determinations. The length of each fish for each year of growth was obtained by back-calculation according to the method of Mansueti (1961). The fish used for this study were caught from November through March.

The extent of annulus formation for 164 striped bass captured November 2 through December 15, 1970, was determined. Of the striped bass captured from November 17-21, only 5.3 percent (3) had developed an annulus. However, by December 2-15, 81.3 percent (87) of the striped bass had developed an annulus. Thus, striped bass apparently develop an annulus from late October early November to late December early January. The peak annulus formation probably occurs in early December.

Since some would lack as much as 7 months growth on the last year, the portion of growth beyond the fishes' last annulus was ignored in age-length calculations. The results of scale analysis and back calculation (Table 10) agree strongly with Mansueti (1961), Merriman (1941), Pearson (1938), and Scofield (1931).

Atlantic Sturgeon - Offshore

A total of 184 Atlantic sturgeon was weighed (kg) and measured (cm). These fish ranged from 40.7 to 216.0 cm and from 0.6 to 113.4 kg. The length-weight relationship is presented in Figure 11. The length-frequency distribution (Figure 12) indicates six peaks: 65.0 cm, 80.0 cm, 95.0 cm, 110.0 cm, 120.0 cm, and 135.0 cm. According to the studies in Canada by Magnin (1962,1964),

Table 10.--Calculated fork length (cm) at the end of each year for striped bass, offshore North Carolina 1968 - 1971

Age group	No. of fish	Mean length at capture (cm)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
I																	
II	13	31.4	14.3	31.4*													
III	37	37.1	9.7	22.3	37.1*												
IV	6	52.2	14.7	28.4	42.2	52.2*											
V	26	57.1	13.2	27.2	40.3	49.3	57.1*										
VI	35	64.1	14.5	26.4	38.9	49.6	58.2	64.1*									
VII	26	72.4	13.4	25.7	36.6	46.5	56.5	65.4	72.4*								
VIII	25	83.0	14.7	27.9	39.7	49.8	60.0	69.1	78.0	83.0*							
IX	38	89.2	14.1	29.1	41.9	51.6	61.2	69.5	77.4	84.3	89.2*						
X	19	94.2	13.7	27.8	39.6	49.2	58.0	66.5	74.3	82.6	89.7	94.2*					
XI	26	97.9	15.2	28.2	40.1	49.1	58.4	67.2	75.5	81.8	88.4	93.7	97.9*				
XII	24	98.8	15.0	26.6	37.4	47.2	56.0	63.8	71.5	78.6	84.8	90.0	95.6	98.8*			
XIII	9	101.2	14.5	25.2	33.4	44.4	51.1	58.7	66.6	75.1	81.5	87.4	93.0	98.5	101.2*		
XIV	5	107.5	15.1	28.1	40.8	52.2	59.9	68.2	75.3	81.3	86.5	91.6	96.9	101.5	105.1	107.5*	
XV	1	111.4	18.7	27.3	33.7	47.2	55.2	63.9	70.8	78.0	85.3	91.4	97.8	102.1	106.8	109.8	111.4*
Mean fork length at end of each year: cm			13.7	26.7	39.2	49.1	58.2	66.7	75.0	81.5	86.8	91.3	95.3	99.8	105.4	109.8	
in			5.4	10.5	15.4	19.3	22.9	26.2	29.5	32.1	34.2	35.9	37.5	39.3	41.5	43.2	
Mean annual growth increment: cm			13.7	13.0	11.8	9.9	9.1	8.5	8.1	7.1	6.5	5.7	5.0	5.1	3.8	3.0	
in			5.4	5.1	4.6	3.9	3.6	3.3	3.2	2.8	2.6	2.2	2.0	2.0	1.5	1.2	
Number of fish:	290		290	277	240	234	208	173	147	122	84	65	39	15	6	1	0

* Incomplete growth year - not used in calculations

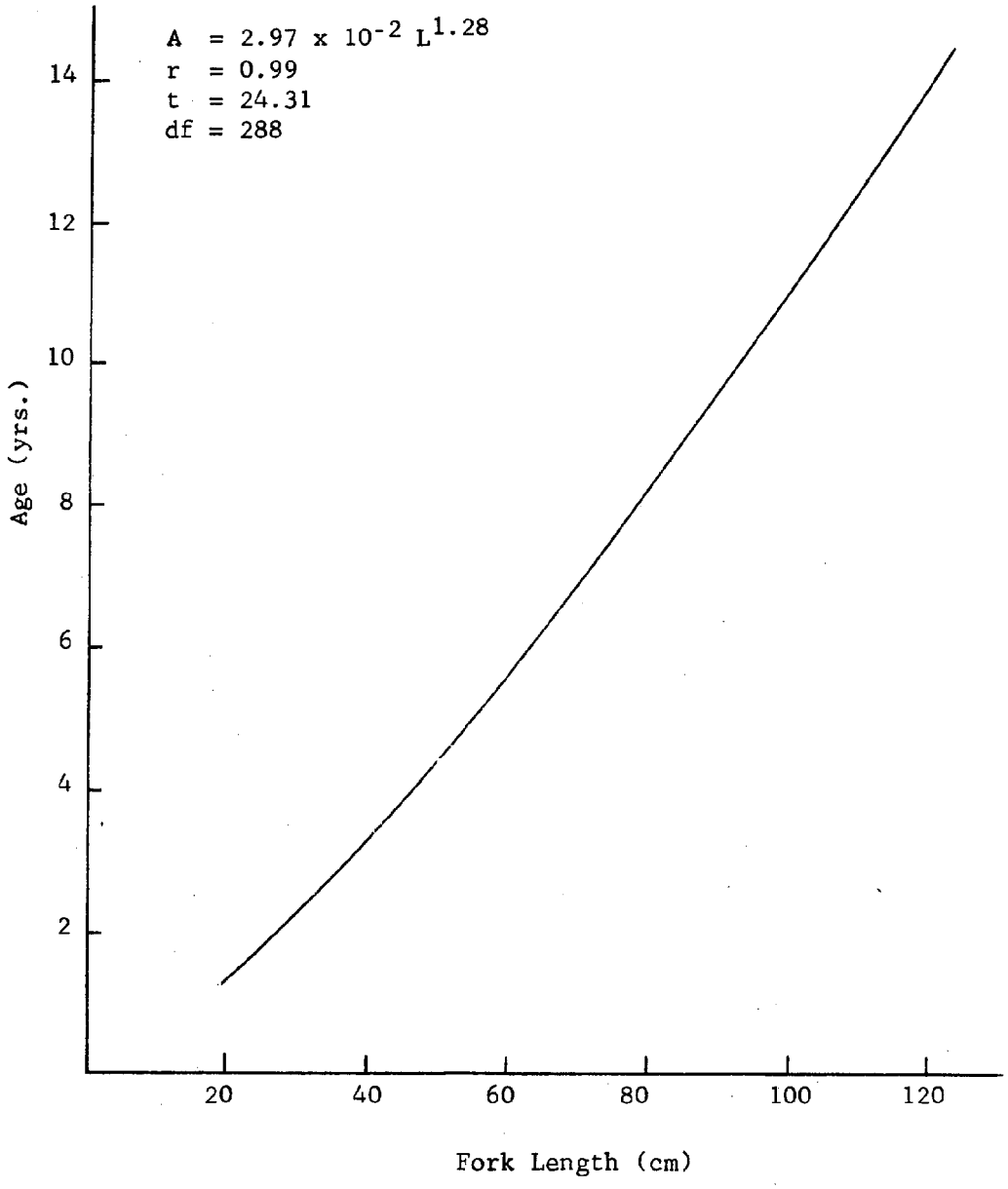


Figure 10.—Calculated age - fork length relationship for striped bass, offshore North Carolina, 1968 - 1971.

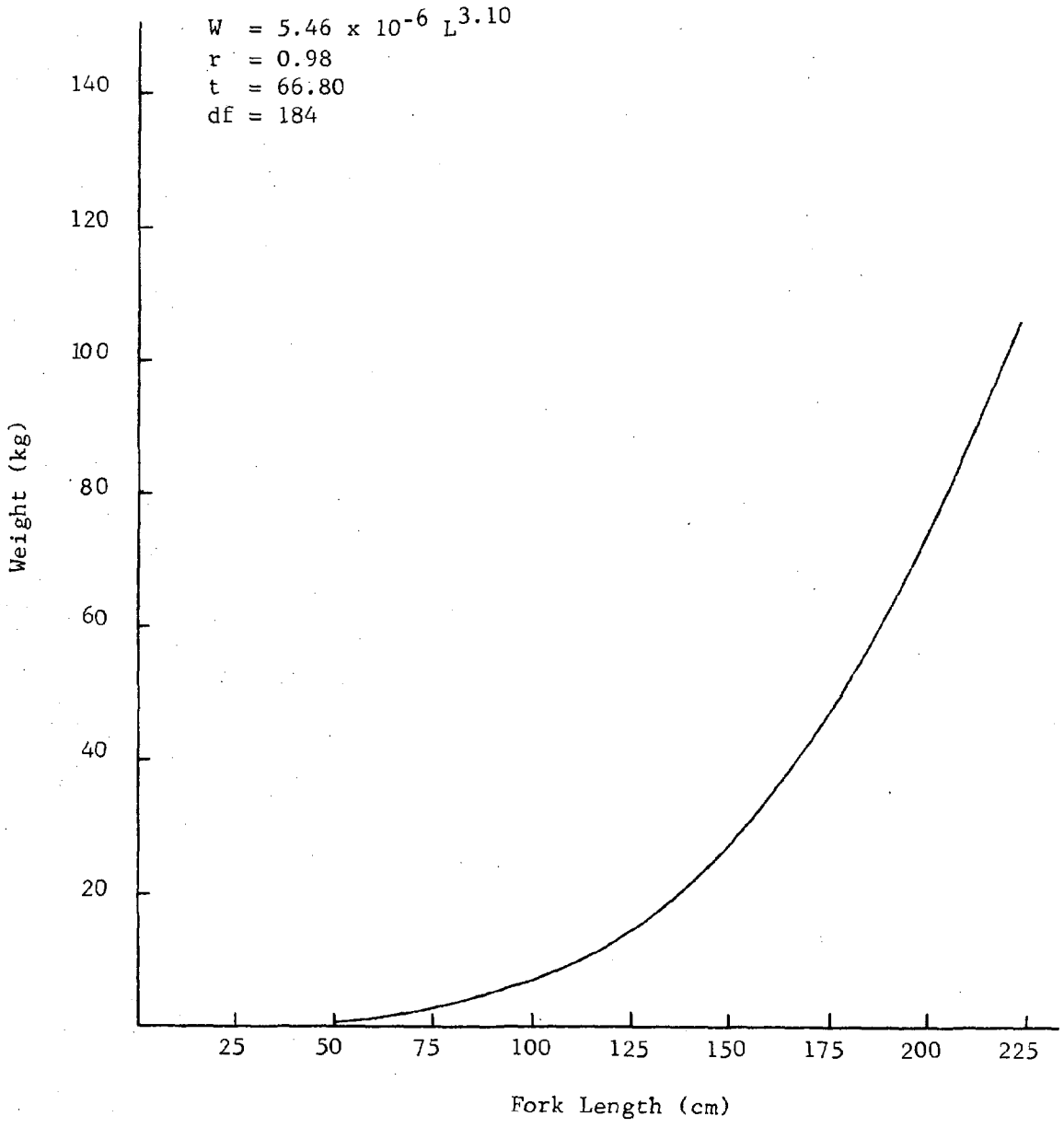


Figure 11.—Fork length - weight relationship for Atlantic sturgeon, offshore North Carolina, 1968 - 1971.

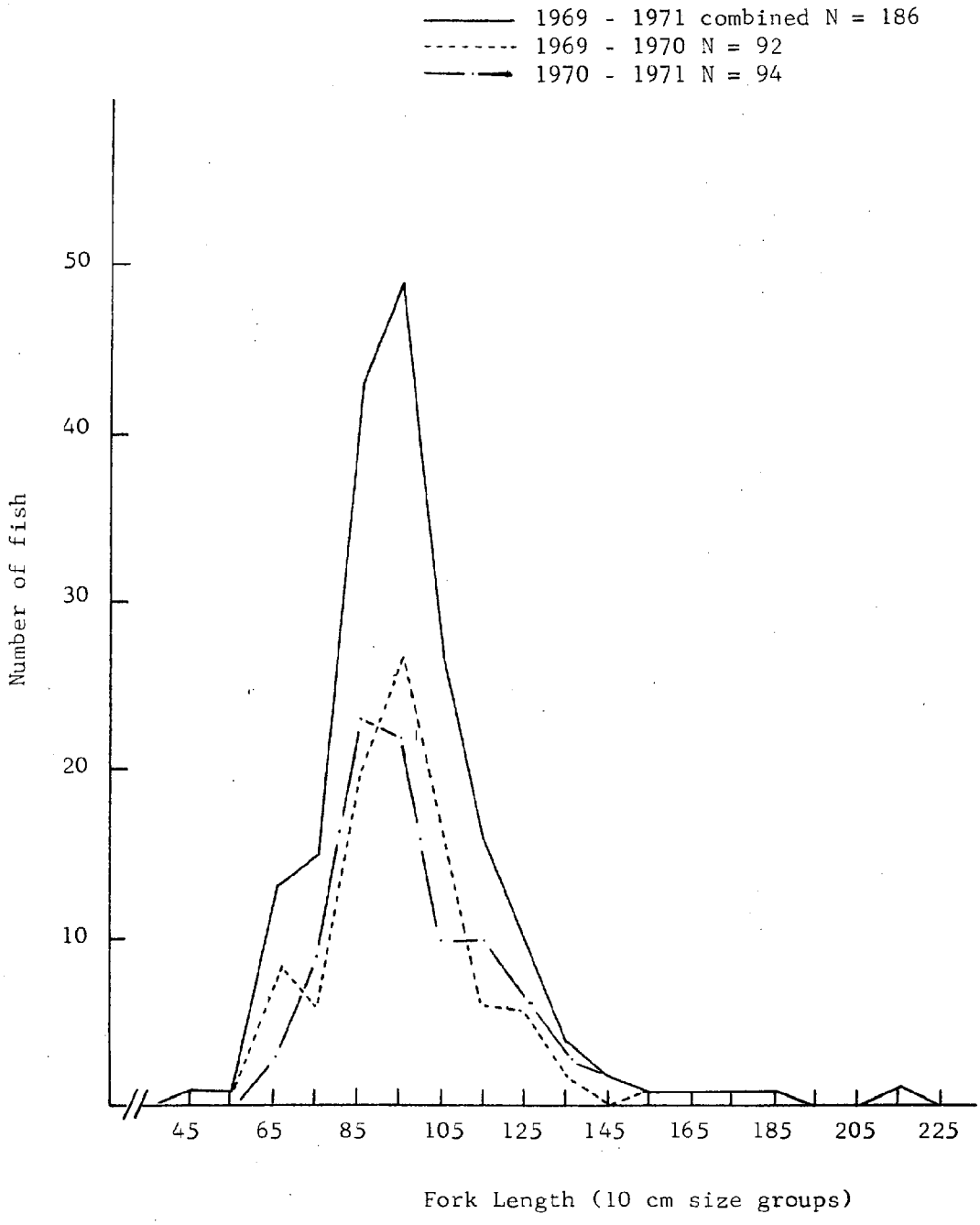


Figure 12.—Length-frequency distribution for Atlantic sturgeon, offshore North Carolina, 1969 - 1971.

fish of these sizes would be approximately 7-8, 9-10, 11-12, 13-14, 15-16, and 17-18 years old respectively. It is probable, however, that North Carolina fish were actually somewhat younger than indicated since Mangnin's work was done in Canada where the fish have a much shorter growing season than in the latitudes of North Carolina. However, no age and growth studies have been conducted on sturgeon in the middle Atlantic area to support or deny this supposition.

American Shad - Offshore

A total of 202 American shad was weighed (kg) and measured (cm). These fish ranged from 8.8 to 54.7 cm and from 0.01 to 2.72 kg. The length-weight relationship is presented in Figure 13.

The length frequency distribution (Figure 14) indicates two peaks: 10.0 to 14.9 cm and 45.0-49.9 cm. These peaks represent fish of 1-2, and 5-9 years old respectively.

A sample of 134 American shad (17.0 to 54.7 cm) was preserved for detailed biological analyses: length, weight, age, fecundity and food habits. Age was determined from scale samples mounted on glass slides. The number of annuli, spawning marks, and age were recorded for the shad and other clupeids using the criteria and methods established by Cating (1953). The scales were always examined by a minimum of two individuals, and only scales on which agreement was reached were used in age determinations. Scale analysis of shad indicated that the fish ranged from 2 to 11 years old, with 80.6 percent falling within the 5-7 year-old range (Table 11), similar to the findings of Walburg and Nichols (1967) for the Delaware and Connecticut Rivers. The data for the relationship between age and fork length are indicated in Table 12 (mean length per age group) and expressed graphically in Figure 15. The mean values from Table 12 are plotted in Figure 15. Even though comparison between these data and the other sources

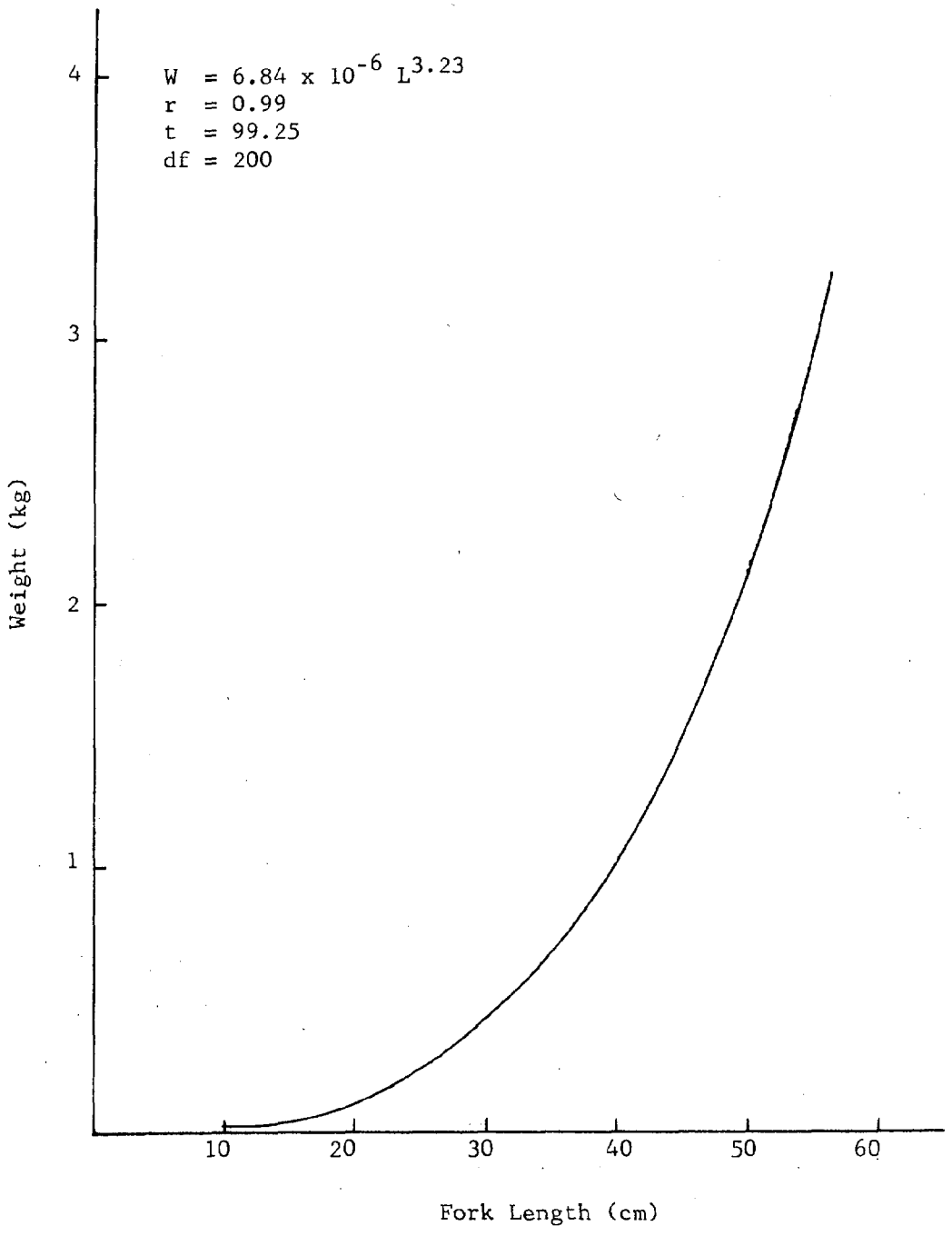


Figure 13 --Fork length - weight relationship for American shad, offshore North Carolina, 1968 - 1971.

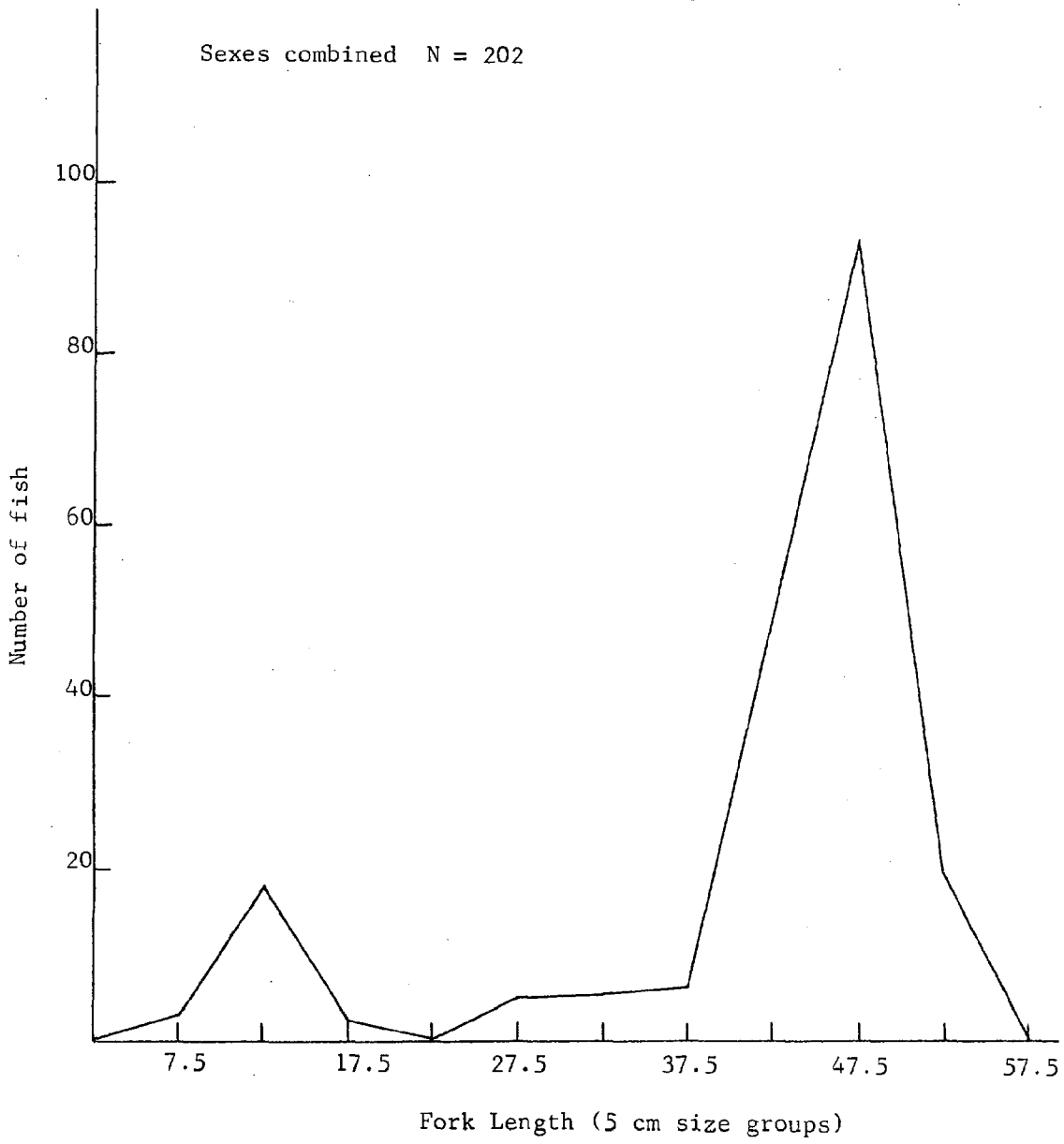


Figure 14.—Length-frequency distribution for American shad, offshore North Carolina, 1968 - 1971.

Table 11.--Age distribution at capture, number of previous spawnings, and age at first spawning for American shad, blueback herring and alewife, offshore North Carolina and Chowan River, January - April 1971 (in percent)

Age at capture (yr. class)	Amer. shad	Offshore	Chowan River	Blue-back herring	Offshore	Chowan River	Alewife	Offshore	Chowan River
I		--	--		--	--		--	--
II		1.5	--		6.6	--		--	--
III		--	--		10.5	--		--	1.5
IV		3.0	--		38.2	20.6		16	33.3
V		10.4	32.4		31.6	39.7		28	37.9
VI		39.6	38.2		6.6	23.5		32	15.2
VII		30.6	29.4		3.9	16.2		20	6.0
VIII		11.2	--		2.6	--		4	6.0
>VIII		3.7	--		--	--		--	--
No. of times spawned previously									
0		28.3	85.3		72.4	42.6		30.0	57.6
1		34.3	11.8		14.5	35.3		34.0	25.8
2		26.9	2.9		6.6	19.1		24.0	10.6
3		7.5	--		3.9	2.9		10.0	4.5
4		3.0	--		1.3	--		2.0	1.5
5		--	--		1.3	--		--	--
Age at first spawning (yr. class)									
III		1.0	--		33.3	--		--	1.5
IV		21.9	5.9		61.9	45.6		60.0	54.5
V		52.1	29.4		4.8	48.5		37.1	39.4
VI		21.9	38.2		--	5.9		2.9	4.5
VII		3.1	26.5		--	--		--	--

Table 12.--Year classes, numbers and mean fork lengths of blueback herring, alewife and American shad from offshore North Carolina and Chowan River compared to other areas along the east coast

Blueback herring

Offshore N. C. Sexes combined			Chowan River					Connecticut River[1]				Georges Bank[2]	
			By sex					By sex				Sexes combined	
Yr. class	No.	Mean length (mm)	Male (no.)	Mean length (mm)	Both sexes (mm)	Female (no.)	Mean length (mm)	Male (no.)	Mean length (mm)	Female (no.)	Mean length (mm)	No.	Mean length (mm)
II	5	163											
III	8	208						16	228	4	231	1	213
IV	29	219	8	225	230	6	236	27	236	7	244	15	238
V	24	235	12	238	242	15	246	118	247	65	257	64	248
VI	5	255	11	238	240	5	246	38	252	65	265	26	258
VII	3	270	5	239	247	6	254	14	263	48	274	7	266
VIII	2	280											

Alewife

Offshore N. C. Sexes combined			Chowan River					Connecticut River[1]				Georges Bank[2]		Lower Chesapeake Bay[3]			
			By sex					By sex				Sexes combined		By sex			
Yr. class	No.	Mean length (mm)	Male (no.)	Mean length (mm)	Both sexes (mm)	Female (no.)	Mean length (mm)	Male (no.)	Mean length (mm)	Female (no.)	Mean length (mm)	No.	Mean length (mm)	Male (no.)	Mean length (mm)	Female (no.)	Mean length (mm)
II												2	162				
III			1	221	221							9	239	--	229	--	239
IV	8	245	15	231	235	7	245	60	234	23	250	35	251	--	239	--	249
V	14	249	18	242	243	7	246	202	245	115	251	29	259	--	249	--	259
VI	16	261	3	256	260	7	262	152	256	154	263	30	269	--	254	--	264
VII	10	270	2	249	259	2	269	48	265	94	271	9	278	--	259	--	274
VIII	2	274	1	266	278	3	284			10	286	4	287			--	282

Table 12 (cont.)

American shad

Offshore N. C. Sexes combined			St. Johns River[4] By sex		Neuse River[4] By sex		Susquehanna River[4] By sex		Delaware River[5] By sex			
Year class	No.	Mean length (cm)	Male-mean length (cm)	Female-mean length (cm)	Male-mean length (cm)	Female-mean length (cm)	Male-mean length (cm)	Female-mean length (cm)	Male no.	Mean length (cm)	Female no.	Mean length (cm)
I			17.5	18.0	17.8	18.3	16.5	17.5				
II			27.7	28.4	28.7	29.5	26.7	28.4				
III			34.5	35.3	36.8	37.6	33.0	36.1	4	37.4		
IV	3	42.9	39.4	40.9	42.2	42.9	37.6	40.4	149	42.6	30	45.1
V	13	45.1		44.7		47.2	40.4	44.4	27	45.8	64	47.6
VI	52	45.8				51.3			2	47.8	19	52.6
VII	40	46.7										
VIII	15	48.6										
IX	3	48.8										
X	1	46.4										
XI	1	54.7										

[1] Marcy, 1969; Data converted from total length to fork length, see Figure 28.

[2] Netzel and Stanek, 1966, July data; Data converted from total length to fork length, see Figure 28.

[3] Jackson and Davis, 1965 - number of fish not given.

[4] LaPointe 1958; calculated fork lengths in inches converted to cm. Numbers of fish: 74 males and 89 females - St. Johns River; 87 males and 77 females - Neuse River; 50 males and 54 females - Susquehanna River.

[5] Chittenden, 1969; 1963 data converted from total length to fork length using Chittenden's conversion figure.

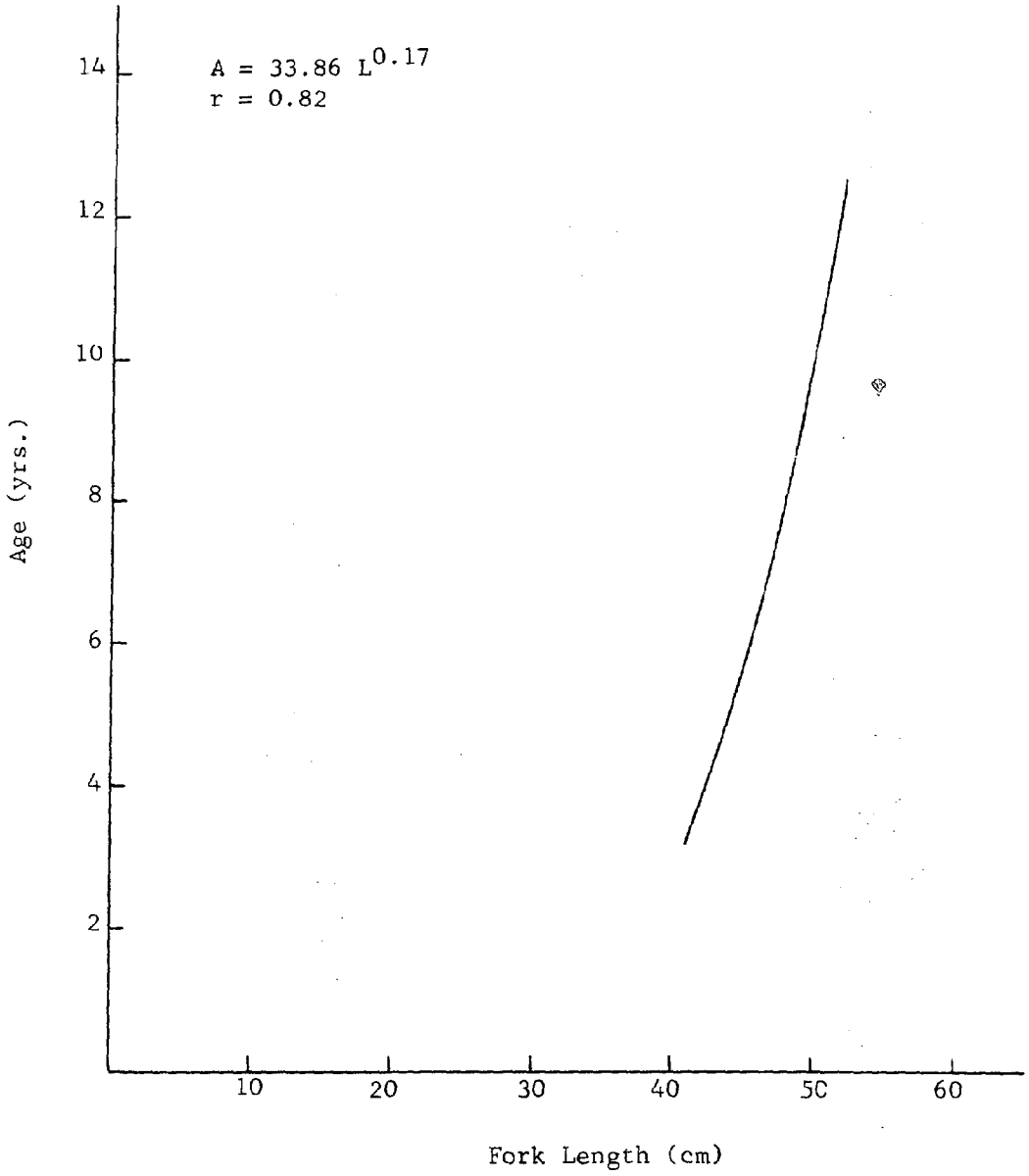


Figure 15.—Fork length - age relationship for American shad sexes combined, offshore North Carolina 1970 - 1971.

listed in Table 12 is available only for the 4-6 year range, these data correspond closely with others.

As indicated by data in Table 11, 71.7 percent of the captured shad had spawned previously, with 3 percent having as many as four spawning marks. This is not typical in North Carolina where repeaters have been found to comprise only three percent of the Neuse River spawning population (Walburg, 1957). Since a higher percentage of repeaters are found north of North Carolina (27% James River and 49% Connecticut River as reported by Walburg and Nichols, 1967), it is likely these shad probably would have spawned north of North Carolina. However, 90 percent of the shad captured offshore were taken on two consecutive days at Oregon Inlet, probably from the same school. The shad may have been migrating inshore by age classes and the school sampled composed primarily of older fish. This could explain the large percentage of repeaters, and the high percentage of 5-7 year olds. Also, as indicated by data in Table 11, 52.1 percent of the American shad spawned the first time at age 5 and 21.9 percent at age 4 and 6.

American Shad - Chowan River at Tunis

A total of 47 American shad was weighed (kg) and measured (cm). These fish ranged from 34.5 to 50.1 cm and from 0.60 to 2.47 kg. Insufficient numbers of American shad were captured to give an accurate length-weight relationship or length-frequency distribution. A total of 34 American shad scale samples were suitable for age determinations. The shad were 5-7 years old (Table 11). This age range did not agree with any literature where 4-6 years was the dominant range. The 5-7 year range does tend to agree with the range found offshore North Carolina. However, no definite correlation can be drawn from 34 fish. For this reason, age class, mean lengths, or age-length regressions were not calculated.

Five American shad, 14.7 percent of the 34 American shad scales suitable for age determination were repeaters (Table 11). Since the Neuse River to the

south had 3 percent repeaters, and James and York Rivers to the north had 27 and 24 percent repeaters respectively (Walburg and Nichols 1967), 14.7 percent repeaters for Chowan River would be expected. Table 11 also indicates 74.5 percent of the shad spawned the first time from ages 4-6. This was similar to shad caught offshore. However, 26.5 percent spawned the first time at age 7. No other river system listed in Walburg and Nichols (1967) had this large a percentage of 7 year old fish. Since the sample was small, larger samples need to be examined before more conclusive statements can be made concerning the growth and spawning of American shad on Chowan River, North Carolina.

Alewife - Offshore

Weight (g) and fork length (mm) were determined for 287 alewife from 1969-1971. These fish ranged from 72 to 305 mm and from 5 to 454 g. The length-weight relationship is shown in Figure 16. The length-frequency distribution (Figure 17) indicates a peak of 120-129 mm in 1969-1970 and a peak of 250-269 mm in 1970-1971. These two peaks would represent 1 and 5-7 year old fish, respectively. The one-year-old alewife were caught in the ocean and were probably leaving the nursery areas for the first time. However, the 5-7 year olds were caught February through March just prior to their spawning run (5-7 year range agrees strongly with Marcy, 1969).

In 1970-1971, a sample of 50 alewife (4-8 years old, Table 11) 224 to 305 millimeters was preserved for detailed biological analysis: length, weight, age and food habits. The fork length-age relationship data for the 50 fish is shown in Table 12 (mean length per age group) and expressed graphically in Figure 18. The mean values from Table 12 are plotted in Figure 18. The data offshore North Carolina agree closely with the other sources listed in Table 12.

Seventy percent of the alewife caught offshore North Carolina had spawned previously: 34 percent once, and 2 percent as much as four times (Table 11),

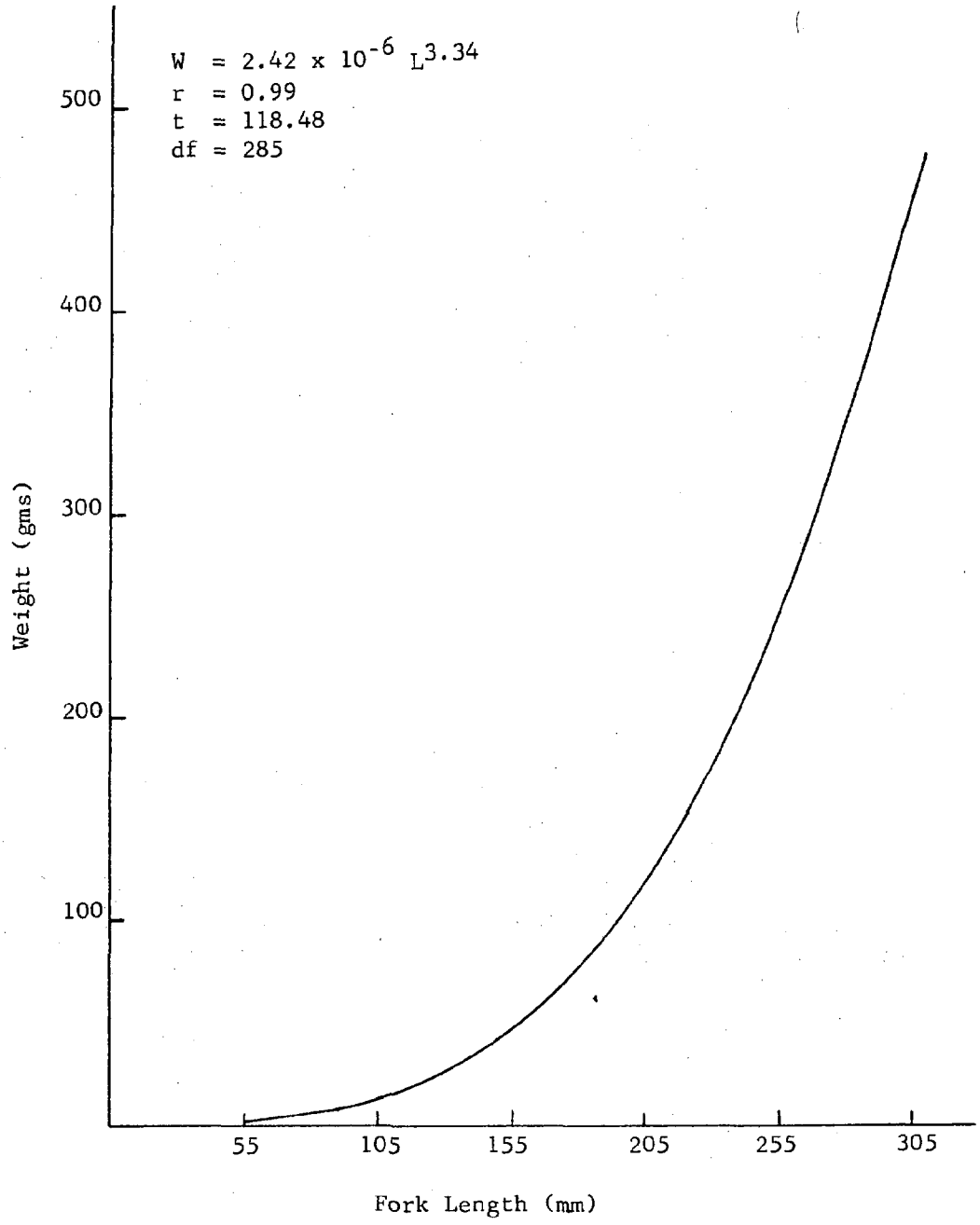


Figure 16.—Fork length - weight relationship for alewife, offshore North Carolina, 1969 - 1971.

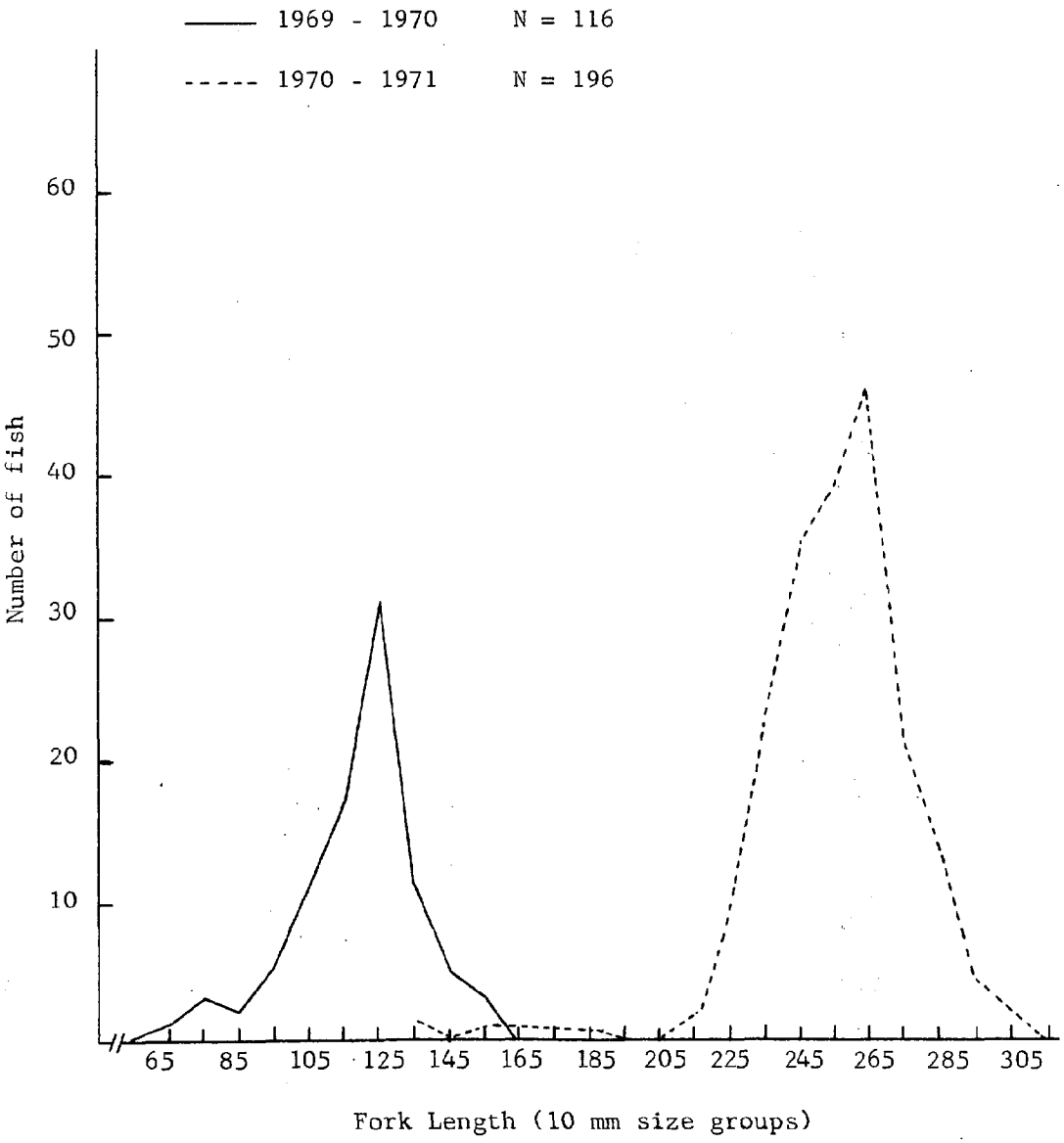


Figure 17.—Length-frequency distribution for alewife, offshore North Carolina, 1969 - 1971.

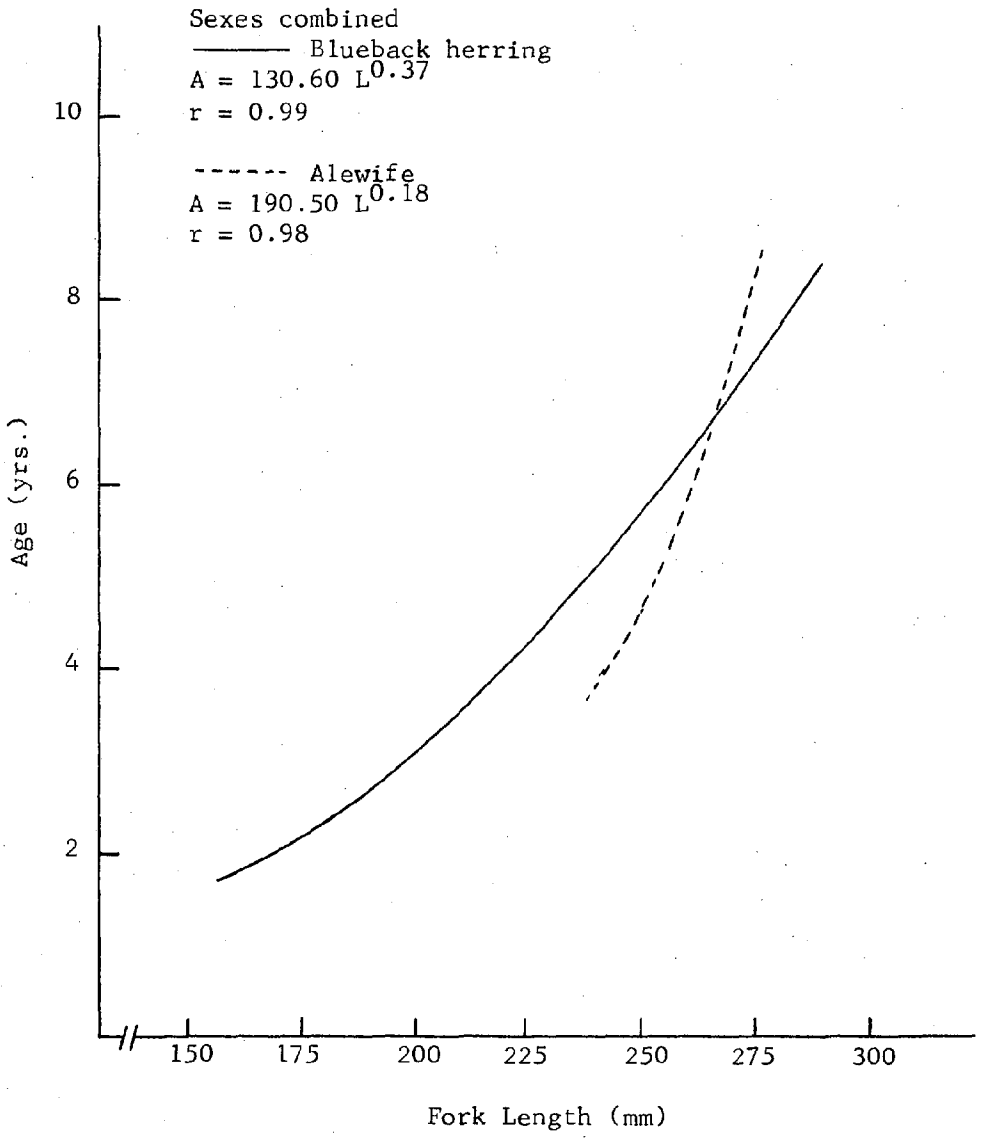


Figure 18.--Fork length - age relationships for alewife and blueback herring offshore North Carolina 1970-1971.

a situation similar to that found by Joseph and Davis (1965) in the York River, Virginia. Sixty percent of the captured alewife had spawned the first time at age 4, 37.1 percent at age 5, and 2.9 percent at age 6 (Table 11). This agrees with Marcy (1969) in Connecticut River.

Alewife - Chowan River at Tunis

A total of 207 male and 180 female alewife was weighed (g) and measured (mm). The males ranged from 214 to 266 mm and 113 to 340 g while the females ranged from 225 to 287 mm and 142 to 397 g.

The length-weight relationship for the total male sample is expressed in Figure 19. In addition to the total male sample, fork length-weight relationships were computed for males at the beginning of the spawning run (1 March) and after the peak of the run (29 March) and are also presented in Figure 19. From these latter two relationships (Figure 19), it is evident male alewife lose approximately 25 grams during spawning.

Female alewife fork length-weight relationships computed for the total sample, pre-peak spawning, and post-peak spawning, are presented in Figure 20. These relationships also indicate a loss in total weight of 30 to 65 grams after spawning, depending upon the length or size of the female fish.

The length-frequency distribution for alewife presented in Figure 21 indicates a peak of 230-259 millimeters for males and 250-269 millimeters for females. Based on the length-age data, these ages would be 4-7 and 5-7 years respectively. This agrees strongly with Marcy (1969) and Netzel and Stanek (1966).

A sample of 40 males, 220 to 266 mm, and 26 females 228 to 287 mm, was preserved for detailed length, weight and age analyses. Scale analysis indicated an age range of 3-8 years for males and 4-8 for females (Table 11). The age-fcrk length relationship data for the 40 males, 26 females, and sexes combined are shown in Table 12 and expressed graphically in Figure 22. The mean values from Table 12 are plotted in Figure 22. As can be seen from the sources

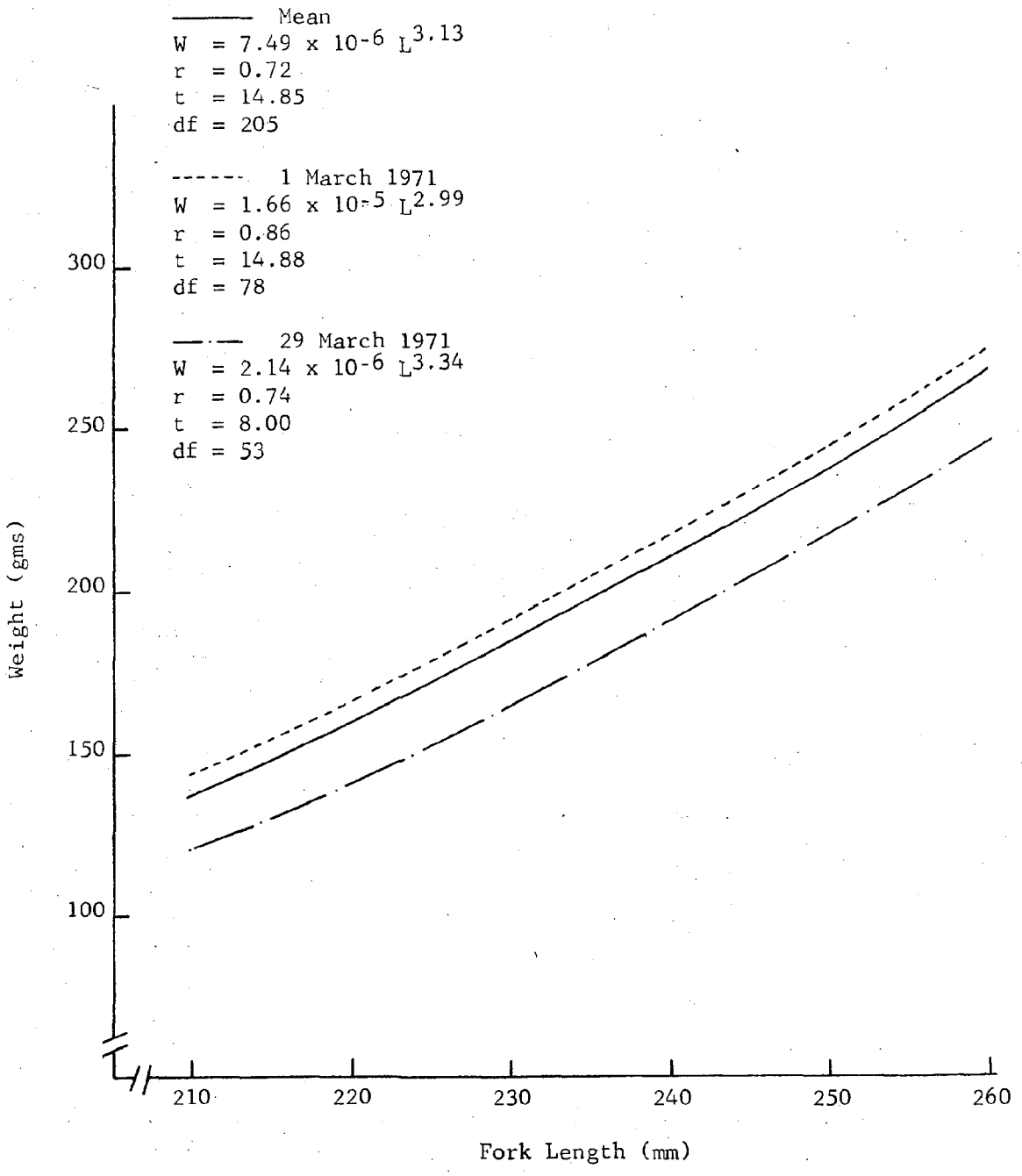


Figure 19.--Fork length - weight relationship for male alewife, Chowan River at Tunis, N. C., 1 March 1971 - 4 May 1971.

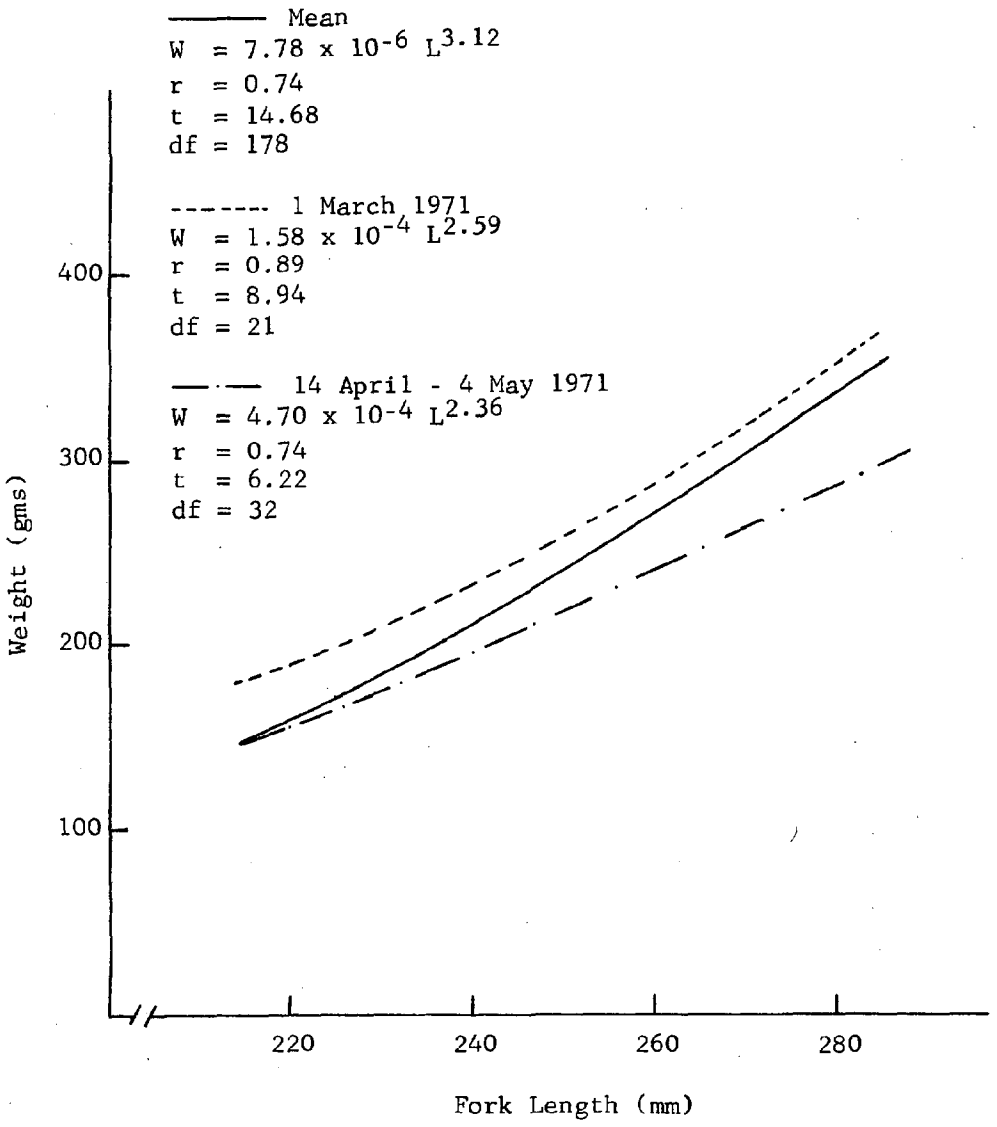


Figure 20.—Fork length - weight relationship for female alewife, Chowan River at Tunis, N. C., 1 March 1971 - 4 May 1971.

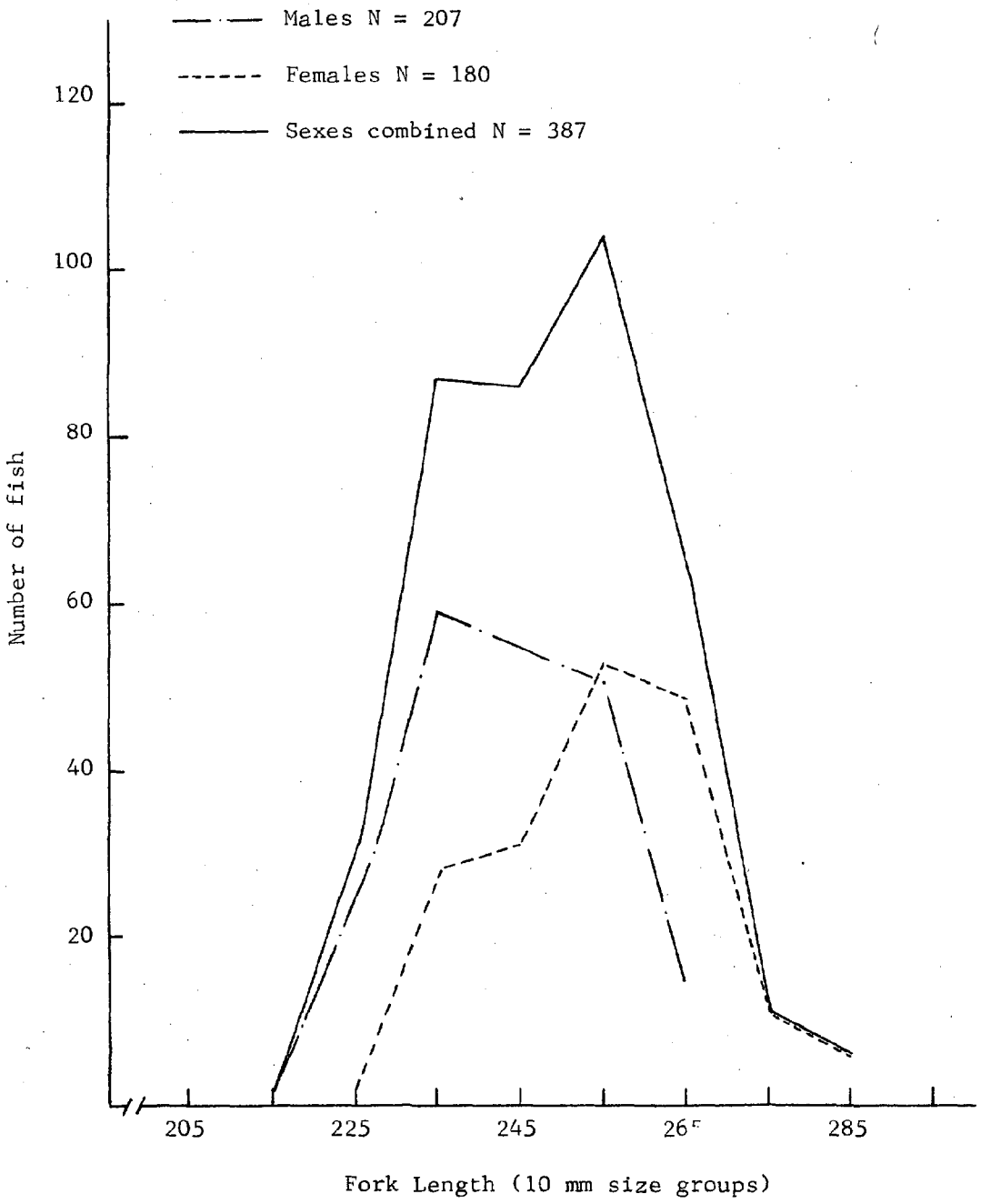


Figure 21.--Length-frequency distribution for alewife, Chowan River at Tunis, N. C., 1 March 1971 - 4 May 1971.

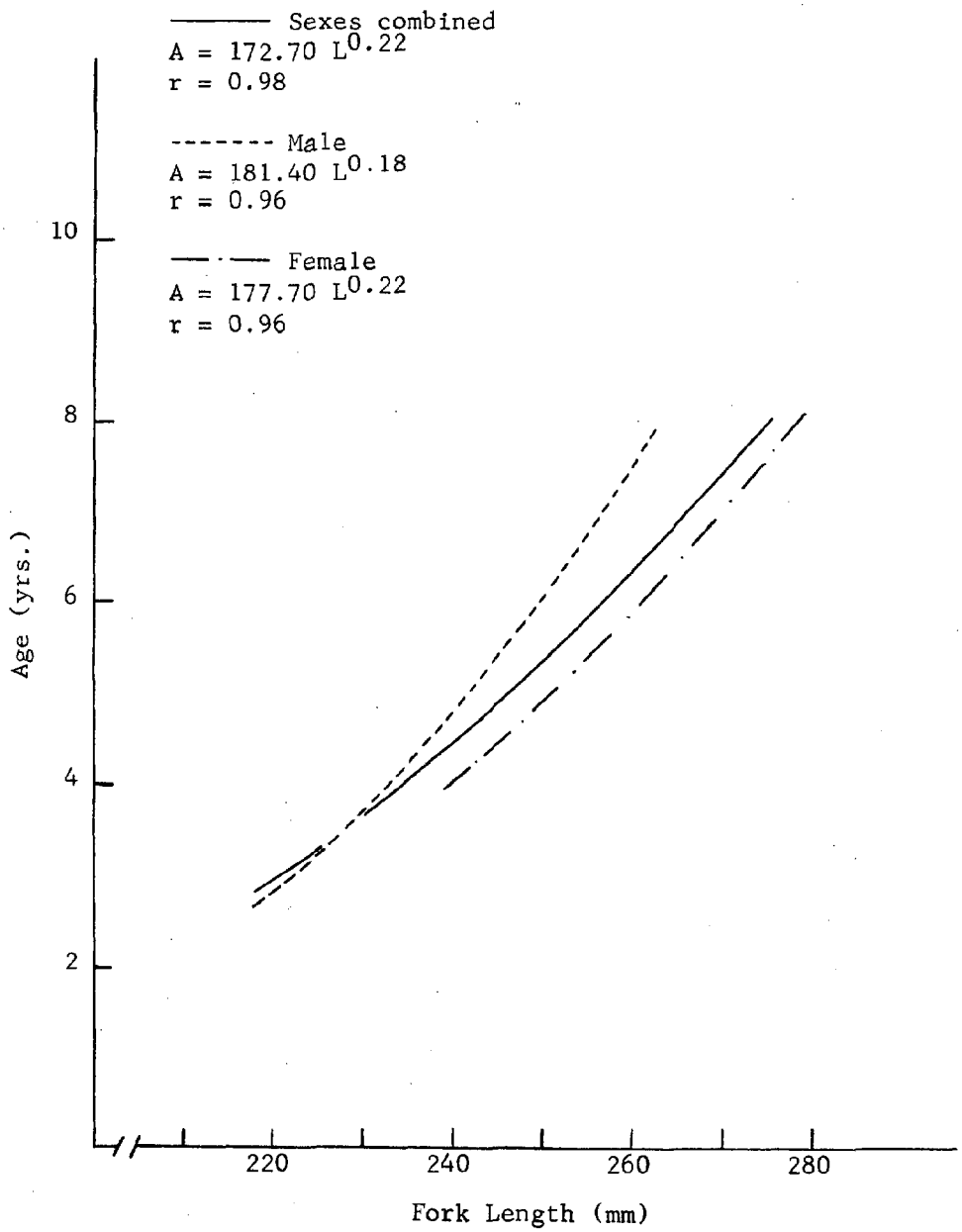


Figure 22.—Fork length - age relationship for alewife, Chowan River at Tunis, N. C., 1 March 1971 - 4 May 1971.

listed in Table 12, Chowan River data agree closely with other sources.

Only 42.4 percent of the alewife in Chowan River had spawned previously, with 25.8 percent having spawned once and 1.5 percent four times (Table 11). This agrees with Joseph and Davis (1965) for fish from the Reedville-Gwynn's Island, Virginia area.

Of the alewife at Tunis, 54.5 percent spawned for the first time at age 4 and 39.4 percent at age 5 (Table 11). Marcy (1969) found a similar situation.

Blueback Herring - Offshore

A total of 186 blueback herring was weighed (g) and measured (mm) from 1969-1971. These fish ranged from 97 to 315 mm and from 28 to 341 g. The length-weight relationship is presented in Figure 23.

The fork length-frequency distribution presented in Figure 24, indicates two major peaks: 220-239 mm for 1969-1970, and 230-249 mm in 1970-1971. According to age-length data, the peaks represent 4-5 and 5-6 year old fish, respectively. The combined two-year sample agrees with the major age composition found by Marcy (1969) and Netzel and Stanek (1966).

A sample of 76 blueback herring, 128 to 315 mm was preserved for detailed length, weight, age, and stomach content analyses. The age-fork length relationship data for the 76 blueback herring are shown in Table 12 and is expressed graphically in Figure 18 (mean values from Table 12 are plotted on Figure 18). The ages ranged from 2-8 years (Table 11) with the mean lengths for the 2-5 year groups smaller than shown by other sources. However, the mean lengths for the 6-8 year groups agreed with the literature.

Only 27.6 percent of the blueback herring from offshore North Carolina were repeaters, 14.5 percent had spawned once, and 1.3 percent had spawned five or more times (Table 11). This percentage of repeaters is lower than that reported by Joseph and Davis (1965) (66 percent repeaters) in the York River, Virginia; and Street and Adams (1969) (80 percent repeaters) in the Altamaha River, Georgia.

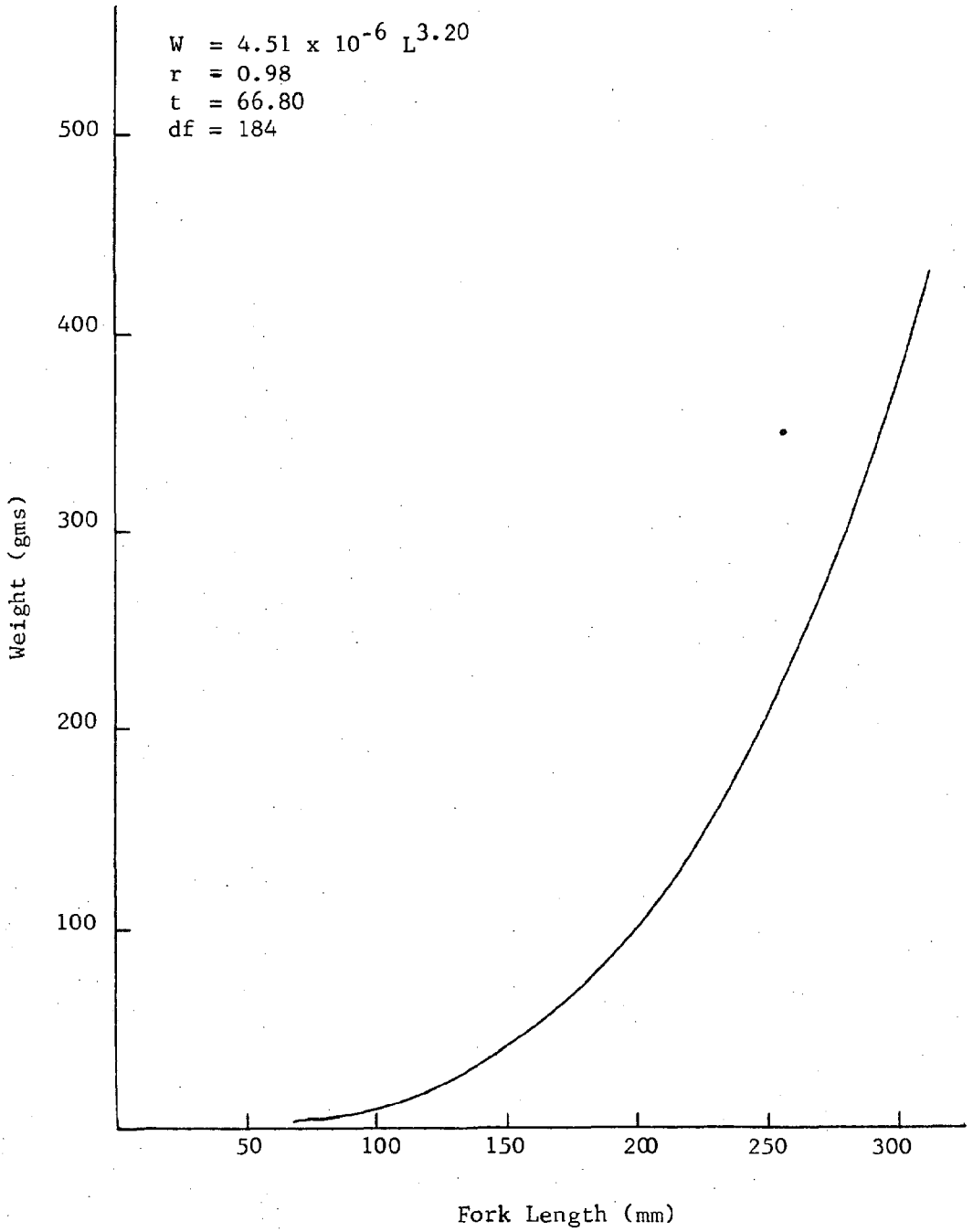


Figure 23.—Fork length - weight relationship for blueback herring, offshore North Carolina 1969 - 1971.

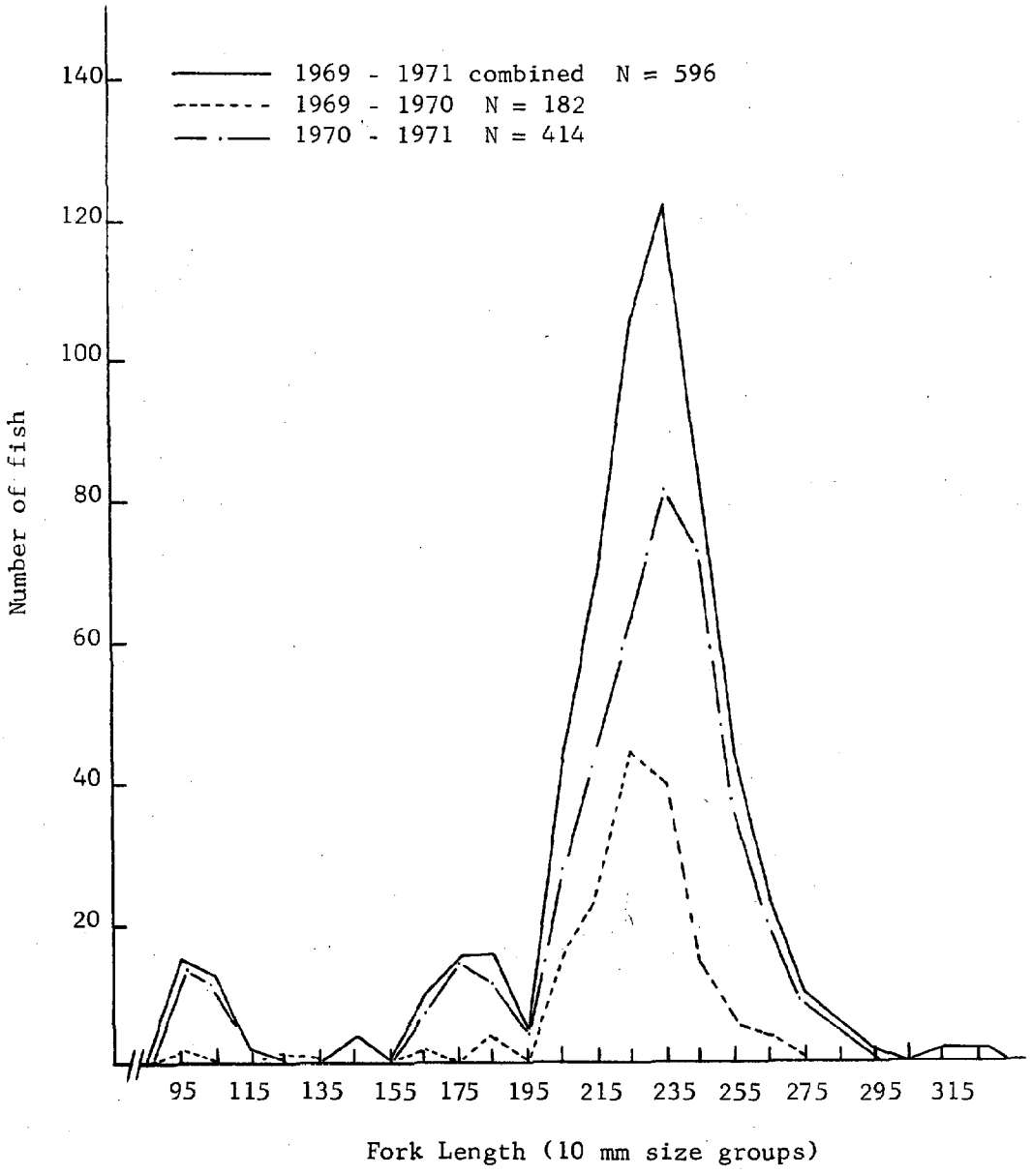


Figure 24.--Length-frequency distribution for blueback herring, offshore North Carolina, 1969 - 1971.

Of the 76 blueback herring, 33.3 percent spawned for the first time at age 3, 61.9 percent at age 4, and 4.8 percent at age 5, (Table 11). These percentages are almost identical to Marcy's (1969) figures for Connecticut River.

Blueback Herring - Chowan River at Tunis

A total of 267 male and 275 female blueback herring was weighed (g) and measured (mm). These fish ranged from 211 to 268 mm and from 113 to 284 g for the males, and 221 to 284 mm, and 142 to 340 g for the females. The length-weight relationship for the total male sample is presented in Figure 25. In addition, length-weight regressions were attempted for males prior to and after the peak of the spawning run. Although there was an evident loss in weight during the spawning run, insufficient numbers of male blueback herring were obtained to derive significant curvilinear relationships prior to and after spawning. Also, males were still in the process of spawning when the last sample was taken.

Fork length-weight relationships were attempted for the females in the same manner as for male blueback herring. However, like the males, the post-spawning relationship could not be computed accurately because ongoing spawning was apparent. Nevertheless, the length-weight relationship was obtained for the total sample and pre-spawning period and is presented in Figure 26.

The length-frequency distribution for bluebacks indicates a peak for males at 230-239 mm and for females at 240-249 mm (Figure 27). According to the length-age data, the above length ranges would represent ages of 4-6 years for both sexes. As with alewife, this 4-6 age range agrees closely with Marcy (1969) and Natzel and Stanek (1966).

A sample of 36 males, 222 to 250 mm, and 32 females, 225 to 260 mm, was preserved for detailed length, weight, and age analyses. When the scale samples were examined, an age range of 4-7 years was found for both sexes (Table 11). The age-fork length relationship data for the 36 males, 32 females, and sexes

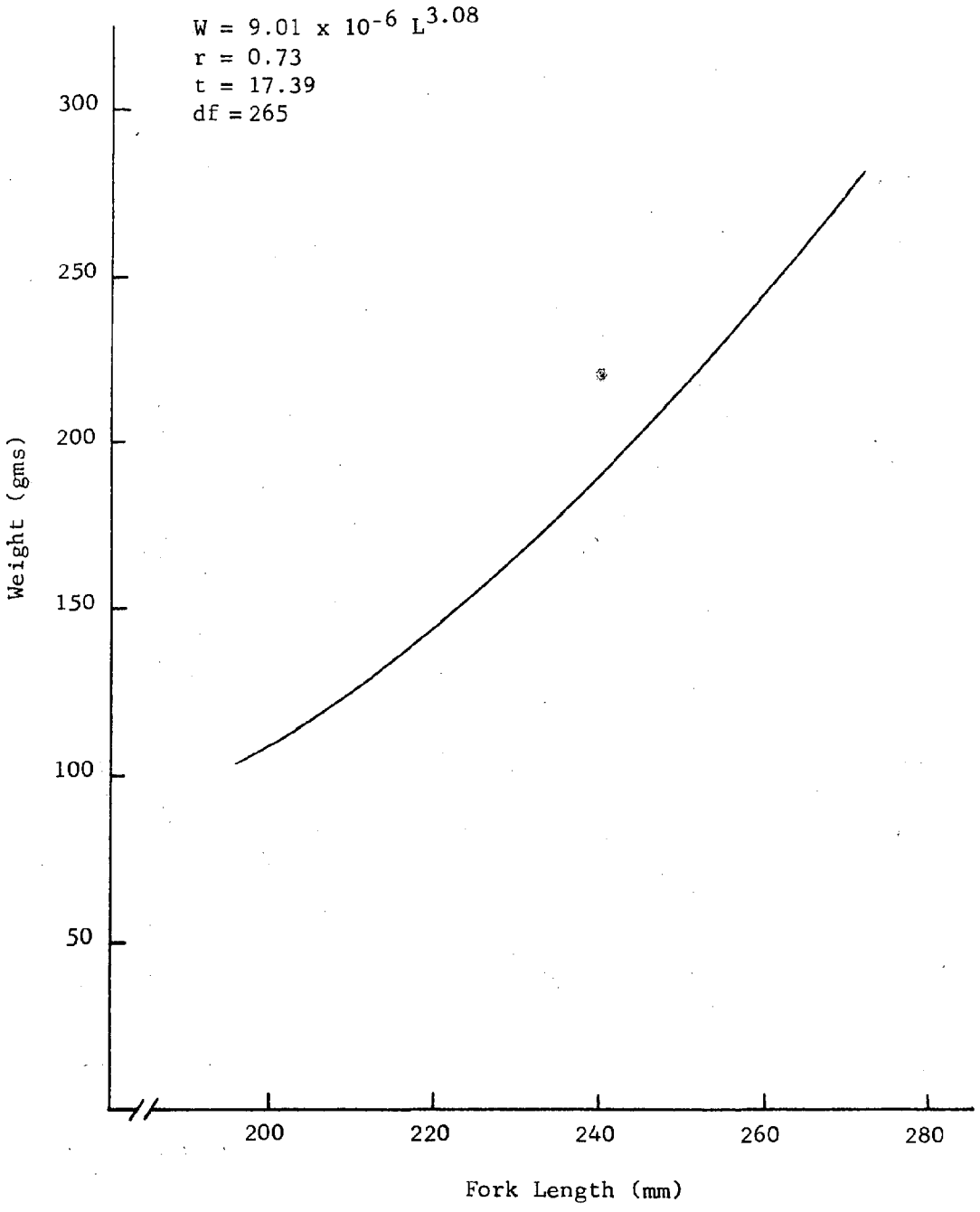


Figure 25.--Fork length - weight relationship for male blueback herring, Chowan River at Tunis, N. C., 21 March - 4 May 1971.

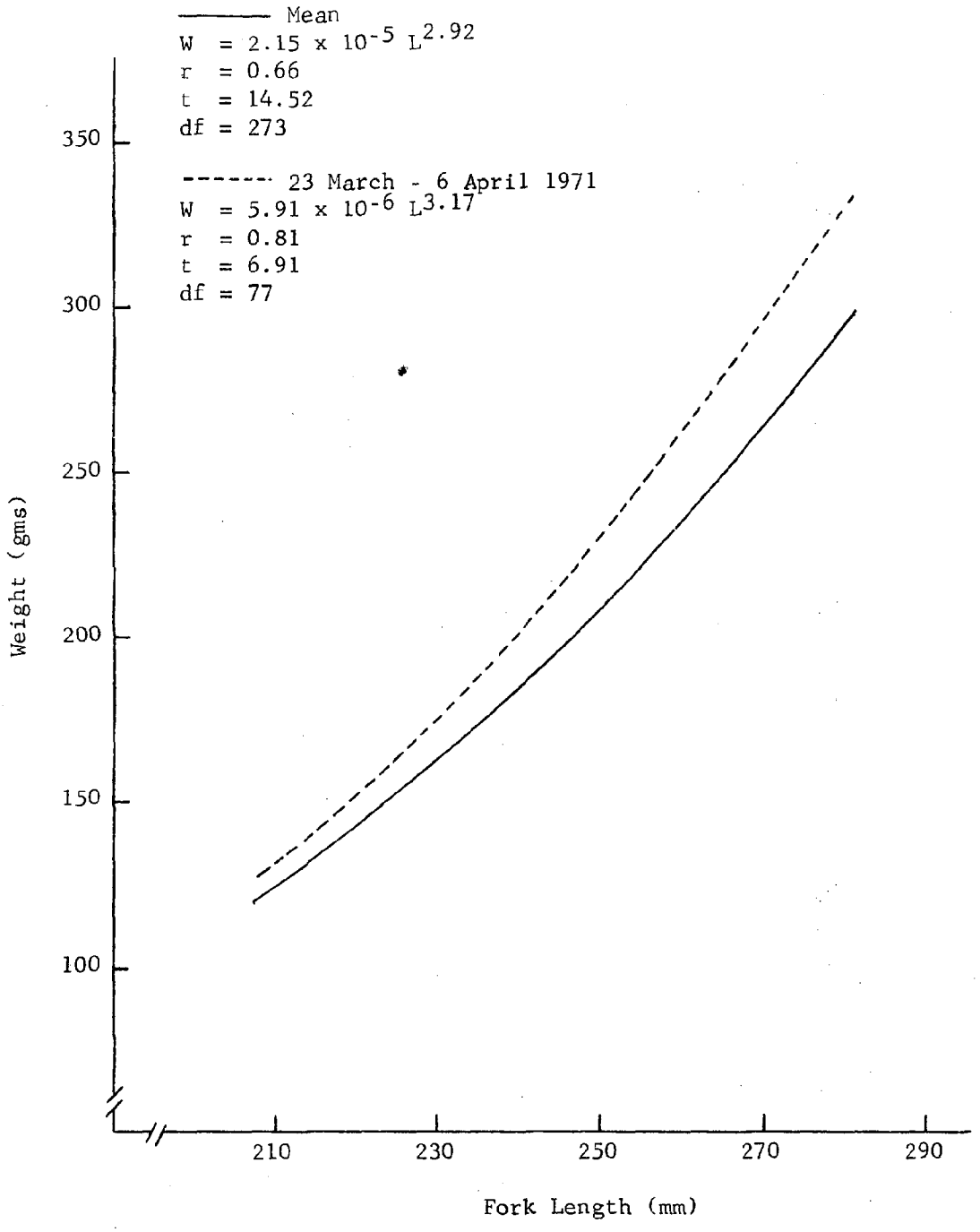


Figure 26.—Fork length - weight relationship for female blueback herring, Chowan River at Tunis, N. C., 21 March - 4 May 1971.

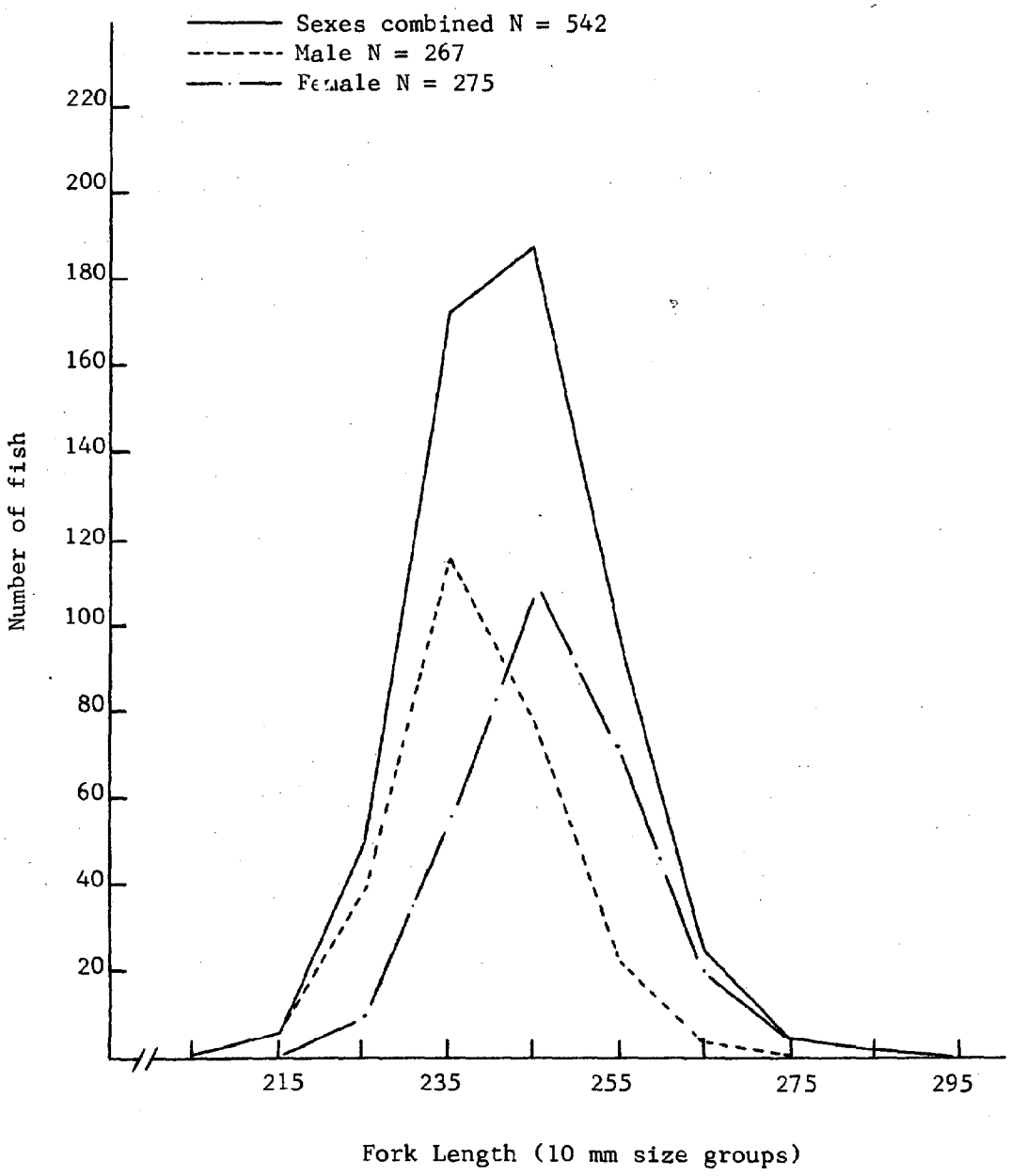


Figure 27.—Length-frequency distribution for male and female blueback herring, Chowan River at Tunis, N. C. 21 March - 4 May 1971.

combined is shown in Table 12 and expressed graphically in Figure 28. The mean values from Table 12 are also plotted in Figure 28. Unlike the alewife at Tunis, there is little or no agreement in the age-length comparisons with the other study sources listed in Table 12. Thus, either our sample was too small (only 10% of the fish sampled had scales taken for age analysis), or the blueback herring at Tunis grow slower than in other areas.

Of the blueback herring captured at Tunis, 57.3 percent had spawned previously with 35.3 percent having spawned once and 2.9 percent three times (Table 11). The total percent repeaters tended to be smaller than that found by Joseph and Davis (1965) and Street and Adams (1969).

At Tunis, 94 percent of the blueback herring spawned for the first time at age 4-5 (Table 11). Marcy (1969) found about 70 percent spawning for the first time at ages 4 and 5 in Connecticut River.

The total length-fork length relationship for blueback herring at Tunis is shown in Figure 29. The formula expressing this relationship was used to convert Marcy's (1969) and Natzel and Stanek's (1966) total length data for blueback and alewife to fork length (Table 12). The total length-fork length relationship for blueback herring and alewife was assumed to be similar.

In summary, the age-length and age at first spawning data for striped bass, American shad and blueback herring offshore, and all alewife, agree well with the findings of researchers in other areas. However, the data for American shad and blueback herring inshore did not agree well with the listed sources, probably, as mentioned before, because of the small sample taken.

Tagging Results

During this three-year study period, 3,147 anadromous fish were tagged off the North Carolina coast (Tables 13, 14, and 15). Most of the fish tagged came

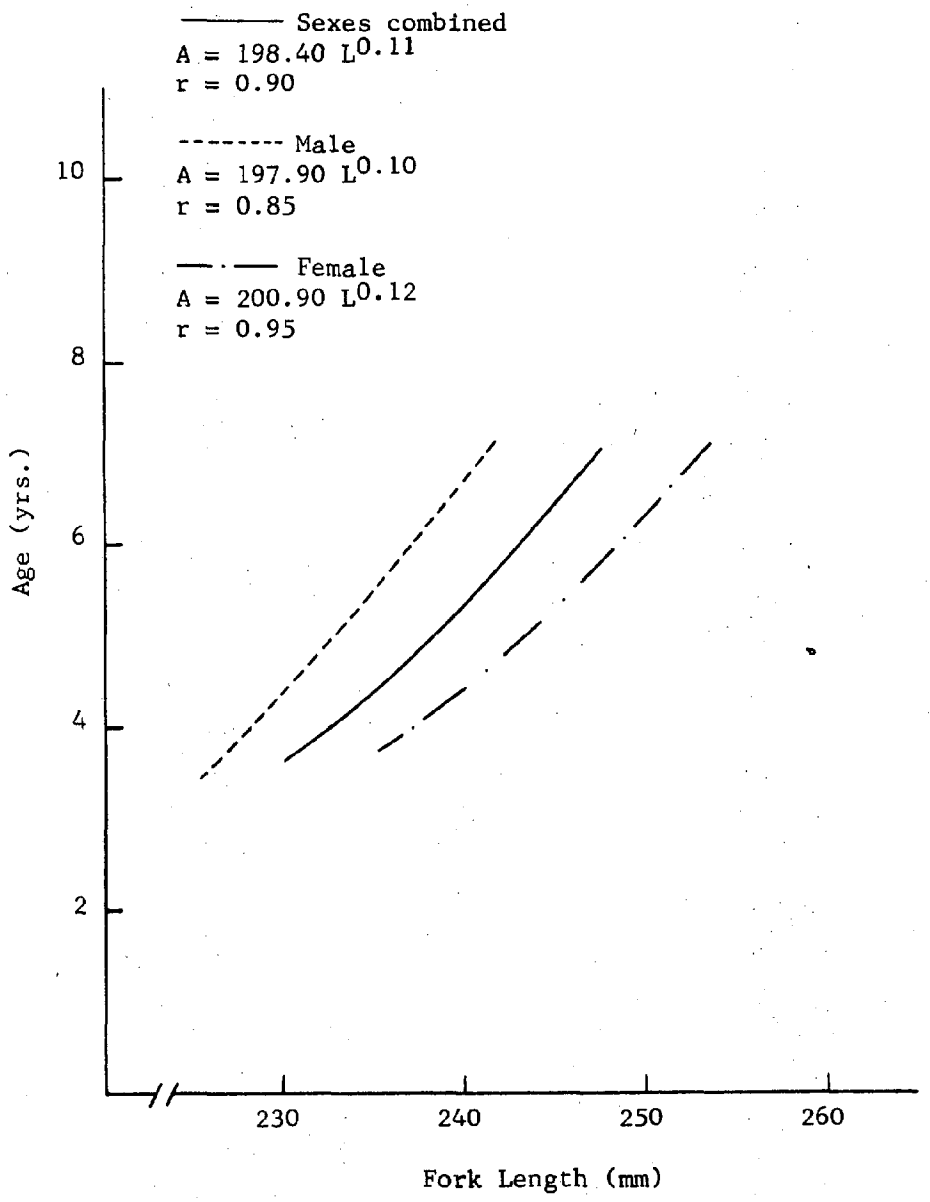


Figure 28.--Fork length - age relationship for blueback herring, Chowan River at Tunis, N. C., 21 March - 4 May 1971.

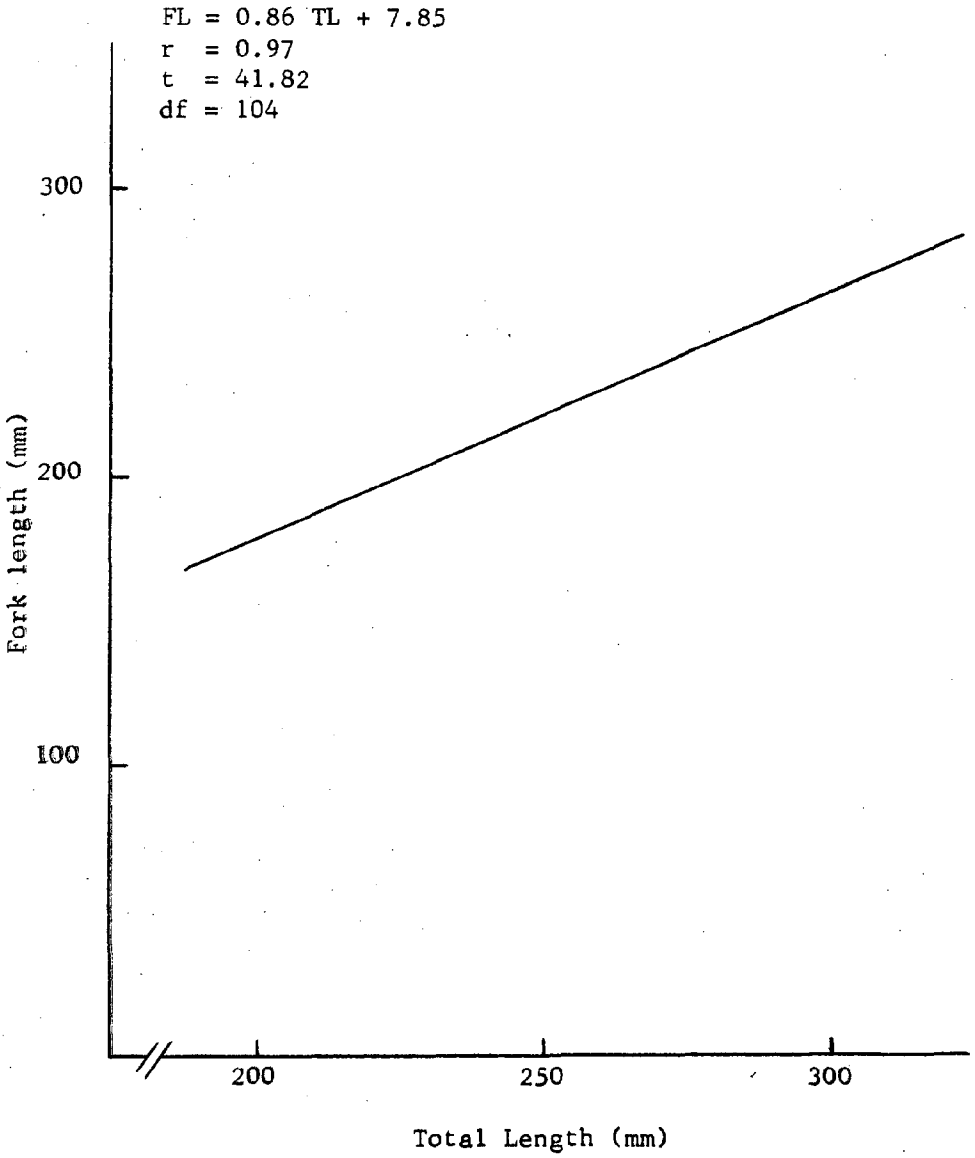


Figure 29.--Total length - fork length relationship for blueback herring, Chowan River, April 26, 1972.

Table 13.--Anadromous fish tagged by area offshore North Carolina, 1968 - 1969

Species	AREA I	AREA II	AREA III	AREA IV	TOTAL
Striped bass (Morone saxatilis)	0	0	2	493	495
American shad (Alosa sapidissima)	0	0	0	5	5
Shortnose sturgeon (Acipenser brevirostrum)	0	0	1	1	2
Atlantic sturgeon (Acipenser oxyrhynchus)	0	0	0	3	3
Blueback herring (Alosa aestivalis)	0	0	0	0	0
Alewife (Alosa pseudoharengus)	0	0	0	0	0
Hickory shad (Alosa mediocris)	0	0	0	0	0
	0	0	3	502	505

Table 14.--Anadromous fish tagged by area offshore North Carolina, 1969 - 1970

Species	AREA I	AREA II	AREA III	AREA IV	TOTAL
Striped bass (Morone saxatilis)	0	0	212	203	415
American shad (Alosa sapidissima)	0	0	0	2	2
Shortnose sturgeon (Acipenser brevirostrum)	0	0	1	0	1
Atlantic sturgeon (Acipenser oxyrhynchus)	0	3	83	4	90
Blueback herring (Alosa aestivalis)	0	9	6	1	16
Alewife (Alosa pseudoharengus)	0	0	18	4	22
Hickory shad (Alosa mediocris)	0	0	0	0	0
	0	12	320	214	546

Table 15.--Anadromous fish tagged by area offshore North Carolina, 1970 - 1971

Species	AREA I	AREA II	AREA III	AREA IV	TOTAL
Striped bass (Morone saxatilis)	0	0	59	783	842
American shad (Alosa sapidissima)	0	0	0	301	301
Shortnose sturgeon (Acipenser brevirostrum)	0	0	0	1	1
Atlantic sturgeon (Acipenser oxyrhynchus)	0	0	10	84	94
Blueback herring (Alosa aestivalis)	0	0	150	467	617
Alewife (Alosa pseudoharengus)	0	0	30	163	193
Hickory shad (Alosa mediocris)	0	0	1	47	48
	0	0	250	1846	2096

from Area IV (2,562). In Area III, 573 anadromous fish were tagged; in Area II, 12 anadromous fish were tagged; and in Area I, no anadromous fish were tagged.

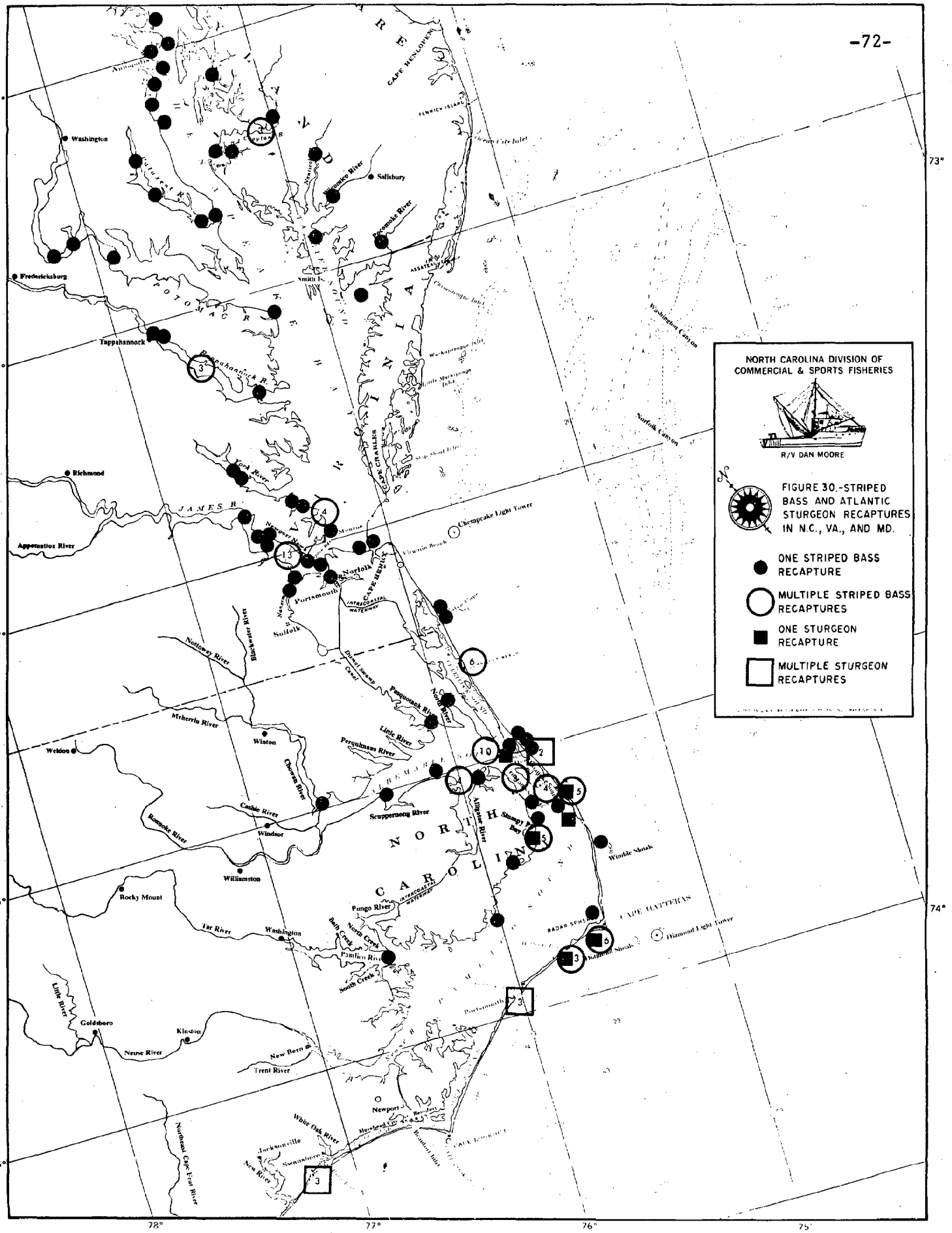
All the tagged striped bass were confined to Areas III and IV, with 84.4 percent being tagged in Area IV. However, during the second segment almost equal numbers of striped bass were tagged in these two areas. All the 308 American shad tagged were captured in Area IV. Only four shortnose sturgeon were tagged, two in Area III and two in Area IV. Of the 187 Atlantic sturgeon tagged, most were tagged in Areas III and IV; however, three were tagged in Area II. Tagging frequency, by area, was almost equally reversed for this species in Areas III and IV during the second and third segments of the study. Blueback herring were tagged most frequently in Area IV, with 25 percent tagged in Area III and less than one percent in Area II. All the alewife were tagged in Areas III and IV with 78 percent being tagged in Area IV. Only 48 hickory shad were tagged during the entire study. One was tagged in Area III and 47 were tagged in Area IV. Of the 1,204 clupeids tagged, none had been returned by 1 November 1971.

As of 1 November 1971, 212 tags had been returned during the three-year study. A total of 197 tag returns came from striped bass and 15 came from Atlantic sturgeon. The overall recapture rates for striped bass and Atlantic sturgeon were 11.2 percent and 8.0 percent, respectively.

Tagging areas are shown in Figure 2. Recapture areas are shown in Figure 30 (Offshore and Inshore North Carolina and Chesapeake Bay), Figure 31 (Upper Chesapeake Bay to Connecticut), Figure 32 (Massachusetts and Cape Cod), and Figure 33 (Maine).

Atlantic Sturgeon

Fifteen tags (8.0%) were returned from the 187 Atlantic sturgeon tagged (Table 16). All 15 were tagged in Areas III and IV. Two of the sturgeon were recaptured in Pamlico Sound and one was recaptured in Albemarle Sound (Figure 30).


NORTH CAROLINA DIVISION OF COMMERCIAL & SPORTS FISHERIES
R/V DAN MOORE
FIGURE 30.-STRIPED BASS AND ATLANTIC STURGEON RECAPTURES IN N.C., VA., AND MD.
ONE STRIPED BASS RECAPTURE
MULTIPLE STRIPED BASS RECAPTURES
ONE STURGEON RECAPTURE
MULTIPLE STURGEON RECAPTURES
39°
38°
37°
36°
35°
73°
74°
78°
77°
76°
75°
Washington
Salisbury
Fredericksburg
Tappahannock
Richmond
Appomattox River
Portsmouth
Norfolk
Chesapeake Light Tower
Weldon
Winton
Windsor
Williamston
Rocky Mount
Washington
Goldsboro
Kinston
New Bern
Newport
Jacksonville
Swansboro
Diamond Light Tower
Wimble Shoals
CAPE HATTERAS
NORTH CAROLINA
VIRGINIA
MARYLAND
POTOMAC R.
RAPPAHANNOCK R.
JAMES R.
YORK R.
CHESAPEAKE BAY
ALBEMARLE SOUND
PAMLICO SOUND
Pocomoke River
Nanticoke River
Wicomico River
Blackwater River
Nottoway River
Meherrin River
Chowan River
Roanoke River
Cashie River
Scuppernong River
Pasquotank River
North River
Perquimans River
Little River
Alligator River
Pungo River
Pamlico River
Bath Creek
North Creek
South Creek
Tar River
Neuse River
Trent River
White Oak River
New River
Northeast Cape Fear River
Dismal Swamp Canal
INTRACOASTAL WATERWAY
CAPE HENLOPEN
FENWICK ISLAND
Washington Canyon
Norfolk Canyon
Suffolk

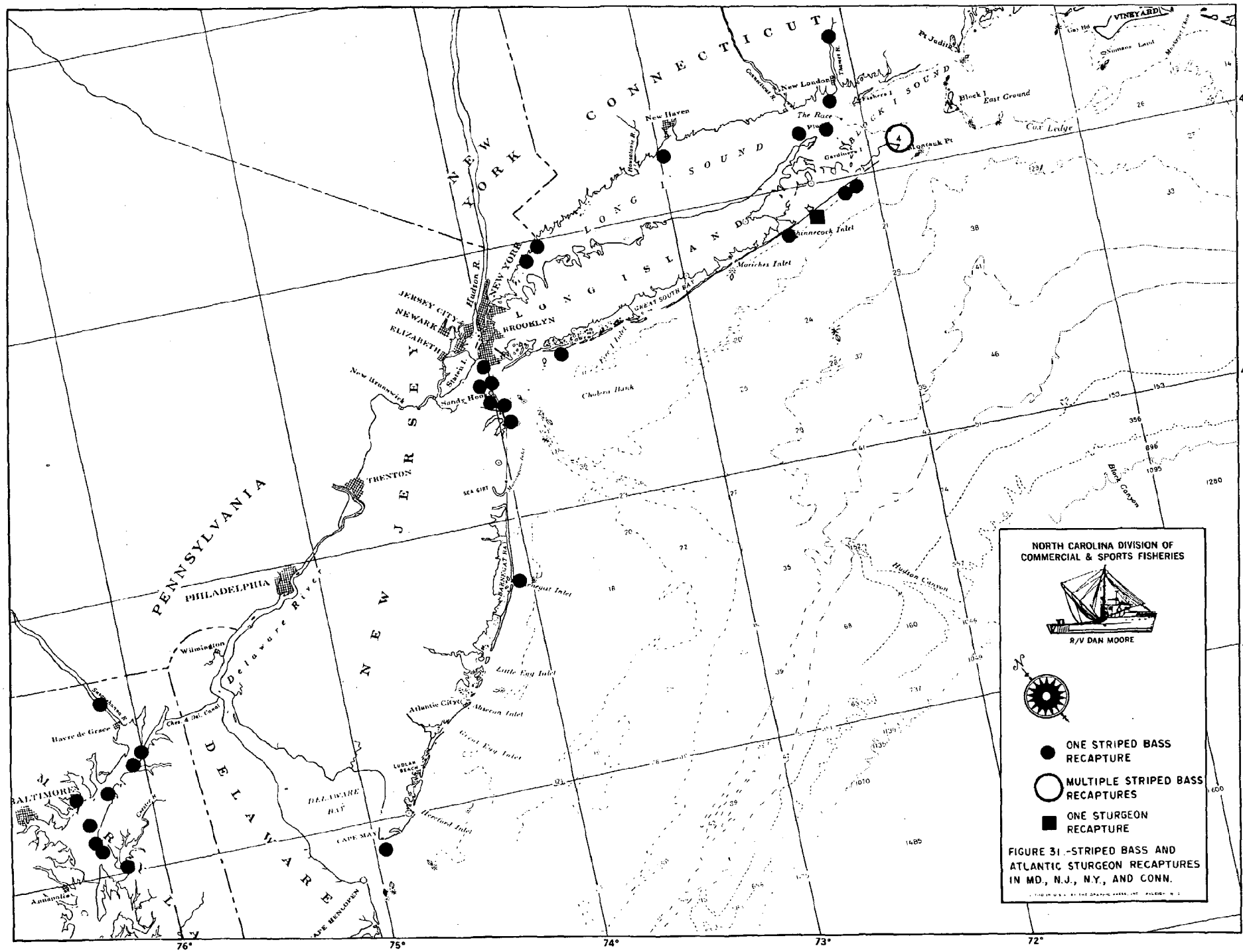


FIGURE 31.-STRIPED BASS AND ATLANTIC STURGEON RECAPTURES IN MD., N.J., N.Y., AND CONN.

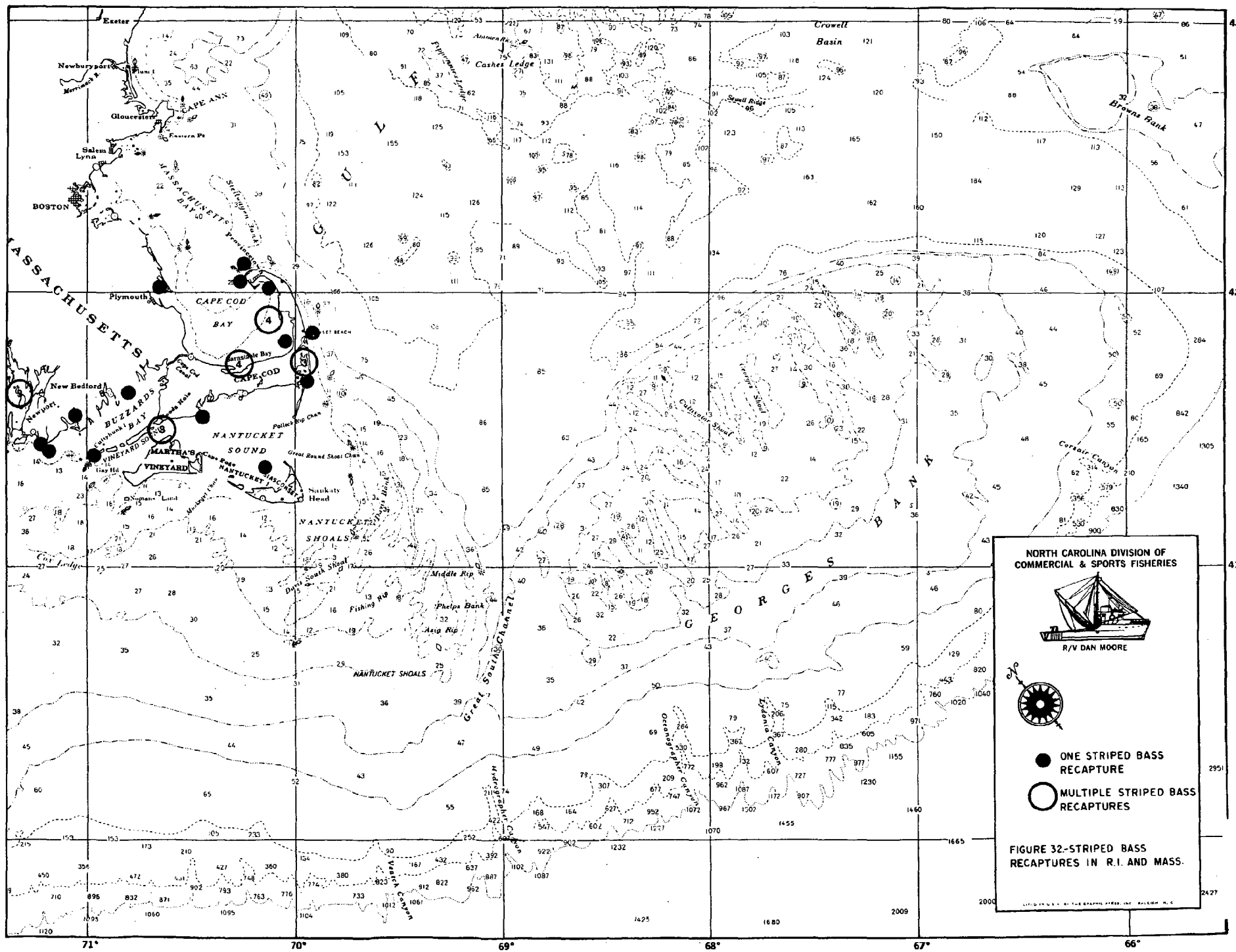


FIGURE 32-STRIPED BASS RECAPTURES IN R.I. AND MASS.

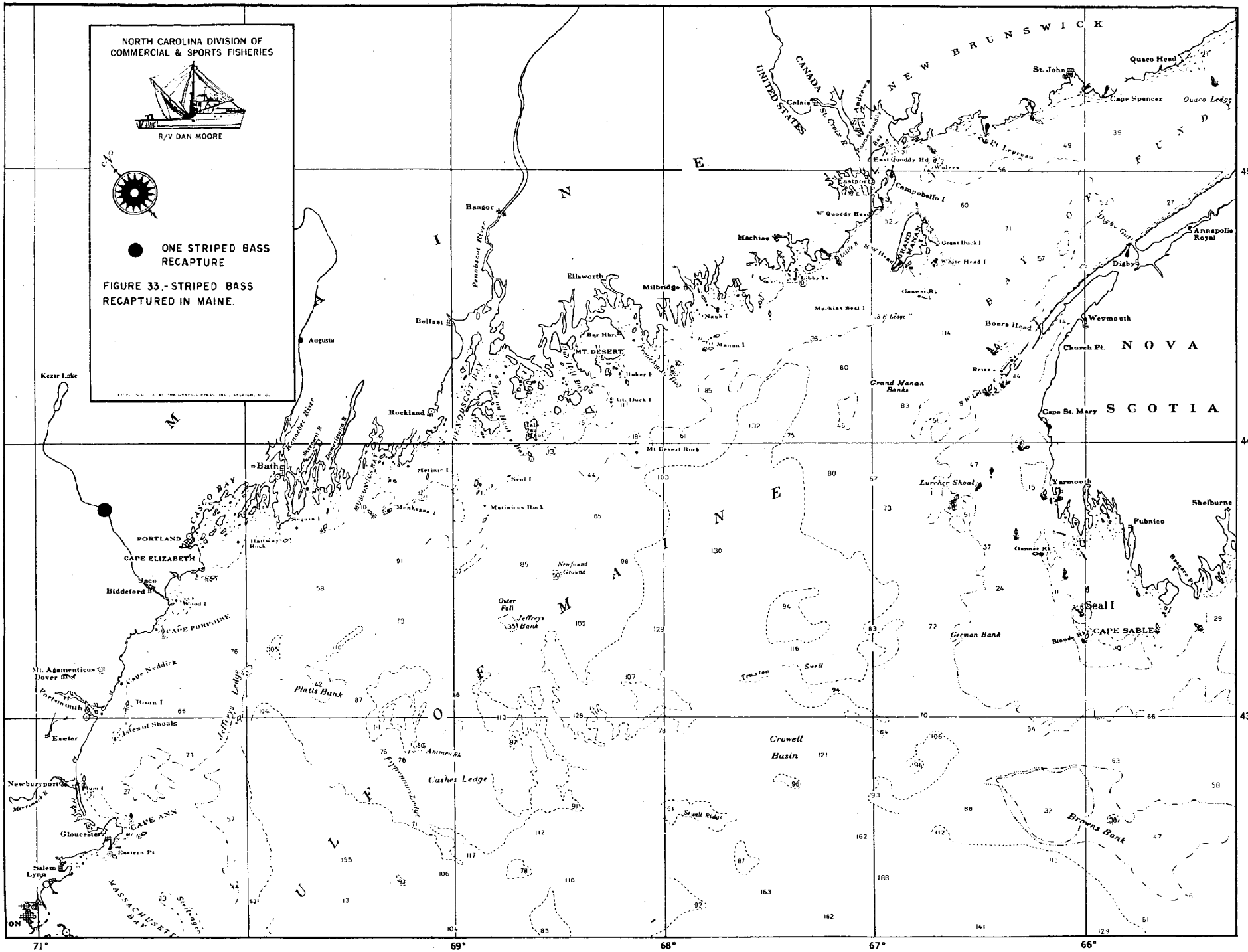

NORTH CAROLINA DIVISION OF
COMMERCIAL & SPORTS FISHERIES
R/V DAN MOORE
ONE STRIPED BASS
RECAPTURE
FIGURE 33.- STRIPED BASS
RECAPTURED IN MAINE.
NEW BRUNSWICK
CANADA
UNITED STATES
NOVA SCOTIA
MAINE
GULF OF MAINE
BAY OF FUNDY
St. John
Quaco Head
Cape Spencer
Quaco Ledge
Calais
St. Croix R.
Passamaquoddy Bay
East Quoddy Hd.
Wolves
Pt. Lepreau
Eastport
Campobello I.
W. Quoddy Head
Machias
Machias R.
Machias Seal I.
S.E. Ledge
Grand Manan
Grand Manan Banks
Great Duck I.
White Head I.
Libby Is.
Gannet Rk.
Bangor
Penobscot River
Ellsworth
Milbridge
Belfast
Augusta
Bar Harbor
MT. DESERT
Baker I.
Gt. Duck I.
Mt Desert Rock
Rockland
Kennebec River
Sheepscot R.
Penobscot Bay
Kezar Lake
Bath
Metinic I.
Seguin I.
Matinicus Rock
Monhegan I.
CASCO BAY
PORTLAND
CAPE ELIZABETH
Halfway Rock
Biddeford
Saco
Wood I.
CAPE PORPOISE
Mt. Agamenticus
Dover
Cape Neddick
Portsmouth
Boon I.
Isles of Shoals
Exeter
Jeffreys Ledge
Platts Bank
Newfound Ground
Outer Fall
Jeffreys Bank
Fippennies Ledge
Cashes Ledge
Annex Rk.
Crowell Basin
Truston Swell
Scull Ridge
German Bank
Browns Bank
Lurcher Shoal
Yarmouth
Shelburne
Pubnico
Seal I.
CAPE SABLE
Gannet Rk.
Boone Head
Weymouth
Church Pt.
Digby
Digby Gut
Annapolis Royal
Briar I.
SW Ledge
Cape St. Mary
Newburyport
Merrimack R.
Plum I.
CAPE ANN
Gloucester
Eastern Pt.
Salem
Lynn
MASSACHUSETTS BAY
Scituate
71°
69°
68°
67°
66°
45°
44°
43°

Table 16.--Summary of recaptured Atlantic sturgeon as of 1 November 1971, tagged offshore North Carolina, December 1968 - March 1971

Season	Tag No.	Date tagged	Location	Date recaptured	Location	Gear	Days out	Net naut. miles trav.	Weight* (kg)	Fork length* (cm)
1969-1970	A00006	3-21-68	Avon	5-25-68	Mecocks, LI, NY	---	65	401	9.5	---
1969-1970	A00388	1-31-70	Ocracoke Is.	2-24-70	Stumpy Pt.Bay NC	Gill net	24	35	2.3	68.6
	A00543	2- 5-70	15 mi.N.Cape Lookout	3- 4-70	Ocracoke sea buoy NC	Trawl	27	25	11.8	108.0
	A00633	2-18-70	Portsmouth Is.	3-16-70	" Inlet NC	Trawl	16	5	9.5	101.1
	A00307	1-16-70	Ocracoke Inlet	3- 6-70	" " "	Trawl	64	5	3.1	70.4
	A00306	1-16-70	" "	3- 7-70	Pamlico Sound (#1 Lt. beacon Rodanthe NC)	Gill net	50	45	2.0	64.0
	A00661	3- 4-70	Portsmouth Is.	3-25-70	Oregon Inlet NC	Trawl	21	66	15.0	121.9
1970-1971	A00676	11-17-70	5 mi. sou. Va. line	12-21-70	Bear Inlet NC	Gill net	35	180	15.0	120.2
	A00782	11-21-70	7 mi. no. Kitty Hawk	---	Hatteras Bight NC	---	--	51	4.5	80.8
	A00687	11-17-70	Currituck Light	4- 3-71	Bear Inlet NC	Gill net	137	200	17.2	130.0
	B00216	12-10-70	Currituck Light	2- 71	Hatteras Inlet NC	Trawl	--	100	4.5	83.0
	B00219	12-10-70	Currituck Light	12-11-70	Kitty Hawk NC	Trawl	1	10	4.5	80.0
	B00220	12-15-70	Currituck Light	12-11-70	Kitty Hawk NC	Trawl	1	10	4.5	78.5
	B00265	12-15-70	15 mi.sou.Oregon Inlet	3-25-71	Bear Inlet NC	Gill net	100	117	16.3	119.3
	B00269	12-15-70	15 mi.sou.Oregon Inlet	12-23-70	Albemarle Sound NC	Gill net	8	--	2.7	69.1
						Mean	51.6	89.3	8.2	92.5

* Weight and length when tagged

One tag was returned during the first segment from Mecocks, Long Island, New York (Figure 31). This sturgeon traveled 401 miles in 65 days at a mean daily rate of 6.2 miles. During the second segment, one sturgeon moved about 25 miles north along the beach, and another traveled over 60 miles north of Portsmouth Island to Oregon Inlet. During the third segment, sturgeon tagged in November and December in Area IV showed a definite tendency to move southward along the coast of North Carolina. Five out of eight recaptures came from Areas II and III. Three were taken in gill nets off Bear Inlet in Area II, 117 to 200 miles south from where they were released. However, during February and March this southward movement appeared to reverse. Four sturgeon tagged during this period were recaptured 5 to 401 miles north of where they were released. The remaining sturgeon were recaptured in the same area they were released. Trawls and gill nets were the methods of recapture. There was no apparent correlation between size of the fish, days out, or distance traveled.

Most of the sturgeon tagged were small (modal group 95.0 to 99.9 cm), and according to studies by Vladykov and Greeley (1963) in the St. Lawrence River, only 2.7 percent of the sturgeon tagged were capable of spawning. Therefore, few returns were expected from inland spawning areas. Instead of any definite inshore spawning migration, tag returns indicated sturgeon were found mostly near the inlets and appeared to move south along the coast from November through January, and northward along the coast during late winter and early spring.

Striped Bass

Tables 17 and 18 indicate the status of striped bass recaptures as of 1 November 1971. The overall recapture rate for the 1,752 striped bass tagged was 11.2 percent. These tag returns, summarized by year and area, suggest several tentative conclusions. Primarily, the inshore zone (0-10 fathoms) between Cape Henry, Virginia, and Cape Lookout, North Carolina, serves as the wintering

Table 17.—Summary of tagged and recaptured striped bass by year and area, February 1969 - 1 November 1971

Season	Number tagged	No. recaptured	Percent	Recaptures in ocean off N.C.		Recaptures in NC estuarine waters		Recaptures in Chesapeake Bay		Recaptures north of Chesapeake Bay	
				No.	Percent	No.	Percent	No.	Percent	No.	Percent
1968-1969	495	54	10.9	5	1.0	4	0.8	40	8.1	5	1.0
1969-1970	415	65	15.7	7	1.7	16	3.9	25	6.0	17	4.1
1970-1971	842	78	9.3	13	1.5	19	2.2	13	3.1	33	3.9
Totals	1752	197		25		39		78		55	
Mean percent recaptures			11.2		1.4		2.3		5.7		3.0
Percent of total recaptures			100.0		12.7		19.8		39.6		27.9

Table 18.—Summary of recaptured striped bass as of 1 November, 1971, tagged offshore North Carolina, December 1968 - March 1971

Season	Tag no.	Date tagged	Location	Date recaptured	Location - OFFSHORE NORTH CAROLINA	Gear	Days out	Net naut. miles trav.	Weight* (kg)	Fork length* (cm)
1968-1969	N00014	1-31-69	False Cape	2- 7-69	Currituck Light	Haul seine	7	10	0.9	37.0
	N00036	1-31-69	False Cape	2-27-69	Kitty Hawk Beach	Unknown	24	30	0.7	35.0
	N00328	2-28-69	Kitty Hawk	3-12-69	Buxton	Unknown	12	39	2.0	53.0
	A00036	1-30-69	False Cape	2- 7-69	Currituck Beach	Unknown	7	9	0.7	34.0
	N00055	1-31-69	False Cape	2- 7-69	Currituck Beach	Unknown	7	10	0.4	33.0
1969-1970	A00168	12-16-69	Currituck-False Cape	1- 1-70	Hatteras Bight	Haul seine	16	82	3.6	64.4
	A00070	12-16-69	Currituck-False Cape	1-15-70	Cape Hatteras Point	Haul seine	30	80	2.4	57.7
	A00199	12-16-69	Currituck-False Cape	1-14-70	2 mi. sou. Oregon Inlet	Trawl	29	47	1.8	52.3
	A00100	12-17-69	Currituck-False Cape	1- 1-70	Corolla Beach	Haul seine	15	. . .	2.3	57.0
	A00122	12-17-69	Currituck-False Cape	1-30-70	1 mi. sou. Oregon Inlet	Haul seine	44	46	1.8	49.3
	A00138	12-17-69	Currituck-False Cape	3-12-70	Corolla Beach	Haul seine	85	10	0.9	39.1
	A00641	2-18-70	Ocracoke Inlet	1- 4-71	Hatteras Inlet	Trawl	320	20	12.7	94.0
1970-1971	A00682	11-17-70	Currituck-False Cape	12- 4-70	Oregon Inlet	Haul seine	17	48	10.0	94.0
	A00697	11-18-70	Currituck Light	---	Hatteras Bight	---	--	71	10.4	95.7
	A00696	11-18-70	Currituck Light	12-21-70	Hatteras Bight	Haul seine	13	75	15.0	104.0
	A00726	11-18-70	Currituck Light	12-25-70	Kitty Hawk	Hook & line	37	24	5.4	79.0
	A00683	11-17-70	Currituck-False Cape	12-16-70	Oregon Inlet	---	29	48	5.0	75.9
	B00081	12- 9-70	Currituck Light	1-11-71	Nags Head	Haul seine	33	30	4.5	70.5
	B00178	12- 9-70	Currituck Light	1-11-70	Hatteras Bight	Haul seine	33	66	2.7	58.5
	A00998	12- 9-70	Currituck Light	1-22-71	Oregon Inlet	Haul seine	44	34	2.7	59.5
	A00985	12- 9-70	Currituck Light	1-26-71	Hatteras Bight	Haul seine	48	67	4.1	69.9
	B00134	12- 9-70	Currituck Light	2- 2-71	Hatteras Inlet	Haul seine	55	86	4.1	65.5
	B00151	12- 9-70	Currituck Light	3- 1-71	Currituck Light	Haul seine	82	7	2.3	56.8
	B00297	12-15-70	Avon	3- 2-71	Hatteras Inlet	Haul seine	77	28	13.2	101.0
	B00467	1-31-71	Oregon Inlet	3- 5-71	4 mi. south Salvo	Haul seine	33	24	4.5	65.7

Table 18 (cont.)

Season	Tag no.	Date tagged	Location	Date recap-tured	Location - INSHORE NORTH CAROLINA	Gear	Days out	Net naut. miles trav.	Weight* (kg)	Fork length* (cm)
1968-1969	N00583	3- 5-69	Kitty Hawk	4- 8-69	Croatan Sound	Pound net	34	29	0.9	40.0
	N00218	2-27-69	Kitty Hawk-Currituck	4- 2-69	Stumpy Point Bay	Gill net	34	37	0.9	40.0
	N00111	2-27-69	Kitty Hawk-Currituck	10-20-69	Albemarle Sound	Gill net	295	--	2.7	61.0
	N00315	2-28-69	4 mi. sou. Kitty Hawk	1-28-71	Point Harbor, Albemarle Sound	Haul seine	699	35	5.1	71.1
1969-1970	A00166	12-16-69	Currituck-False Cape	1-26-70	Pledger Landing, Albemarle Sound	Gill net	42	85	2.3	52.9
	A00169	12-16-69	Currituck-False Cape	2- 6-70	Point Peter, Pamlico Sound	Gill net	52	55	2.3	54.2
	A00300	12-16-69	Currituck-False Cape	1-15-70	Stumpy Point Bay	Gill net	30	65	2.7	59.7
	A00087	12-16-69	Currituck-False Cape	2-12-70	Collington Harbor	Haul seine	59	63	1.4	46.5
	A00099	12-17-69	Currituck-False Cape	2- 2-70	Pasquotank River	Gill net	48	85	1.8	47.0
	A00112	12-17-69	Currituck-False Cape	12-31-69	Laurel Point, Albemarle Sound	Gill net	14	90	2.0	51.0
	A00118	12-17-69	Currituck-False Cape	1-15-70	Alligator River	Gill net	29	70	1.1	43.0
	A00139	12-17-69	Currituck-False Cape	1-15-70	Alligator River	Gill net	29	70	1.1	42.4
	A00140	12-17-69	Currituck-False Cape	1-15-70	Albemarle Sound entrance	Gill net	29	70	1.4	44.0
	A00141	12-17-69	Currituck-False Cape	1-26-70	Cypress Swamp, Albemarle Sound	Gill net	40	80	1.4	43.4
	A00215	12-18-69	Kitty Hawk-Currituck	1-26-70	Cypress Swamp, Albemarle Sound	Gill net	39	80	1.6	48.3
	A00064	12-16-69	Currituck-False Cape	2- 9-70	Stumpy Point Bay	Gill net	55	55	1.4	46.8
	A00101	12-17-69	Currituck-False Cape	---	Roanoke Sound	Haul seine	--	46	1.1	43.5
	A00290	12-18-69	Kitty Hawk-Currituck	---	Roanoke Sound	Haul seine	--	36	3.4	62.4
	A00347	1-17-70	Hatteras Inlet	3-30-70	South Roanoke Sound	Haul seine	72	40	10.9	88.5
	A00152	12-16-69	Currituck-False Cape	4- 9-70	Point Harbor, Albemarle Sound	Haul seine	114	70	1.6	50.0
1970-1971	B00165	12- 9-70	Currituck Light	12-12-70	Manns Harbor Bay	Gill net	3	45	3.2	66.1
	B00096	12- 9-70	Currituck Light	1-11-70	Albemarle Sound	Gill net	33	--	3.6	63.2
	B00289	12-15-70	Avon	1-14-71	Roanoke Sound	---	30	31	6.3	76.6
	B00129	12- 9-70	Currituck Light	1-22-71	Albemarle Sound entrance	Gill net	44	60	2.3	59.6
	A00996	12- 9-70	Currituck Light	2- 2-71	Albemarle Sound entrance	Gill net	55	63	4.5	73.0
	B00481	1-31-71	Oregon Inlet	2-11-71	Long Shoal Rv., Pamlico Sound	Gill net	11	26	3.2	58.7
	B00415	1-29-71	Avon - Oregon Inlet	2-13-71	Pamlico River	Pound net	15	--	2.0	51.8
	B00448	1-31-71	Oregon Inlet	2-18-71	Gull rock, Pamlico Sound	Gill net	18	41	6.3	75.2
	B00432	1-29-71	Chicamacomico	2-22-71	Stumpy Point Bay	Gill net	24	29	2.7	56.3
	A00963	12- 9-70	Currituck Light	2-17-71	Albemarle Sound entrance	Gill net	7	58	4.5	74.3
	A00877	12- 8-70	Kitty Hawk	3- 1-71	Coinjock, North River	Gill net	83	42	3.6	69.0

Table 18 (cont.)

Season	Tag no.	Date tagged	Location	Date recap-tured	Location - INSHORE NORTH CAROLINA	Gear	Days out	Net naut. miles trav.	Weight* (kg)	Fork length* (cm)
1970-1971	B00493	2-12-71	Avon - Chicamacomico	3- 1-71	Stumpy Point Bay	Gill net	17	30	2.3	53.5
	B00431	1-29-71	Chicamacomico	3- 5-71	Pamlico Sound entrance	---	35	16	2.3	51.0
	B00552	3-12-71	Oregon Inlet	3-16-71	Manns Harbor Bridge	Gill net	4	15	3.6	61.7
	B00535	3-12-71	Oregon Inlet	3-12-71	Albemarle Sound	Hook & line	10	--	3.2	56.6
	B00097	12- 9-70	Currituck Light	3-17-71	Stumpy Point	---	98	65	2.7	62.1
	B00546	3-12-71	Oregon Inlet	3-22-71	Albemarle Sound entrance	Gill net	10	32	4.5	70.0
	B00223	12-13-70	Currituck Light	3-29-71	Croatan Sound	2-boat trawl	106	55	4.5	72.0
	B00436	1-29-71	Oregon Inlet	---	Chowan River entrance	Gill net	--	88	3.2	58.9
						Mean	64.3	53.0	2.9	57.5

Table 18 (cont.)

Season	Tag no.	Date tagged	Location	Date recap-tured	Location - CHESAPEAKE BAY	Gear	Days out	Net naut. miles trav.	Weight* (kg)	Fork length* (cm)
1968-1969	N00214	2-27-69	Kitty Hawk- Currituck	3-11-69	Poquoson Rv., Virginia	Pound net	13	69	0.7	37.0
	N00521	3- 5-69	Kitty Hawk	4- 5-69	Choptank Rv., Maryland	Pound net	31	173	0.9	38.0
	N00026	1-31-69	False Cape	4- 8-69	Maryland Point, Maryland	Gill net	67	61	0.9	40.0
	A00029	1-30-69	False Cape	3-20-69	James Rv., Virginia	Gill net	48	63	0.9	41.0
	N00204	2-27-69	Kitty Hawk-Currituck	3-28-69	Nells Cr., Virginia	Haul seine	29	74	0.7	36.0
	N00284	2-27-69	Kitty Hawk-Currituck	3-31-69	Grove Point, Maryland	Gill net	33	208	1.1	44.0
	N00244	2-28-69	Kitty Hawk	---	Steel fleet James Rv., Virginia	Gill net	--	112	1.4	45.0
	N00162	2-27-69	Kitty Hawk-Currituck	3-21-69	Hampton, Virginia	Pound net	22	97	0.4	32.0
	N00346	2-28-69	Kitty Hawk	3-17-69	Sandbridge, Virginia	Haul seine	17	46	1.1	44.0
	N00350	2-28-69	Kitty Hawk	3-26-69	Chesapeake, Virginia	---	26	95	0.9	39.0
	N00405	2-28-69	Kitty Hawk	3-19-69	Elizabeth River, Portsmouth, Va.	---	19	90	0.7	37.0
	N00261	2-27-69	Kitty Hawk-Currituck	3-17-69	Fort Eustis, Virginia	Gill net	18	85	0.9	40.0
	B00489	2-28-69	Kitty Hawk	5-15-69	Nansemond Rv., Virginia	---	15	92	0.9	41.0
	N00279	2-27-69	Kitty Hawk-Currituck	3-17-69	Back Rv., Virginia	Pound net	18	69	0.9	42.0
	N00155	2-27-69	Kitty Hawk-Currituck	3-17-69	Back Rv., Virginia	Pound net	18	69	1.1	42.0
	N00412	2-28-69	Kitty Hawk	3-17-69	Back Rv., Virginia	Pound net	17	81	0.7	35.0
	N00353	2-28-69	Kitty Hawk	4-16-69	Patuxent Rv., Maryland	---	47	126	0.9	39.0
	N00382	2-28-69	Kitty Hawk	4-28-69	Rock Hall, Maryland	---	59	198	0.9	39.0
	N00047	1-31-69	False Cape	4-12-69	Choptank Rv., Maryland	Gill net	71	145	0.7	36.0
	N00109	2-27-69	Kitty Hawk-Currituck	4-12-69	Choptank Rv., Maryland	Gill net	44	122	1.1	42.0
	A00018	1-30-69	False Cape	4- 2-69	Fishing Pt., James Rv., Virginia	Haul seine	61	63	0.7	38.0
	N00063	1-31-69	False Cape	4- 2-69	Fishing Pt., James Rv., Virginia	Haul seine	61	63	0.9	39.0
	N00280	2-27-69	Kitty Hawk-Currituck	4- 2-69	Fishing Pt., James Rv., Virginia	Haul seine	34	88	0.9	40.0
	N00319	2-28-69	Kitty Hawk	4- 2-69	Fishing Pt., James Rv., Virginia	Haul seine	33	103	1.1	44.0
	N00396	2-28-69	Kitty Hawk	4- 2-69	Fishing Pt., James Rv., Virginia	Haul seine	33	103	0.7	37.0
	N00336	2-28-69	Kitty Hawk	4- 2-69	Fishing Pt., James Rv., Virginia	Haul seine	33	103	0.9	41.0
	N00411	2-28-69	Kitty Hawk	4- 2-69	Fishing Pt., James Rv., Virginia	Haul seine	33	101	0.7	35.0
	N00444	3- 5-69	Kitty Hawk-Currituck	4- 2-69	Fishing Pt., James Rv., Virginia	Haul seine	28	95	0.9	40.0
	N00462	2-28-69	Kitty Hawk	4- 2-69	Fishing Pt., James Rv., Virginia	Haul seine	33	101	2.5	59.0
	N00486	2-28-69	Kitty Hawk	3- 5-69	Deal's Is., Maryland	Hook & line	5	142	0.9	41.0
	N00051	1-31-69	False Cape	3-28-69	Fishing Pt., James Rv., Virginia	Haul seine	56	63	0.4	32.0
	N00471	2-28-69	Kitty Hawk	4- 2-69	Fishing Pt., James Rv., Virginia	Haul seine	33	103	2.5	59.0

Table 18 (cont.)

Season	Tag no.	Date tagged	Location	Date recaptured	Location - CHESAPEAKE BAY	Gear	Days out	Net naut. miles trav.	Weight* (kg)	Fork length* (cm)
	N00438	3- 5-69	Kitty Hawk-Currituck	5- 8-69	Susquehanna Rv., Md.	Gill net	64	223	0.7	37.0
	N00488	2-28-69	Kitty Hawk	4-15-69	Pocomoke Rv., Md.	Gill net	46	143	0.9	41.0
	N00138	2-27-69	Kitty Hawk-Currituck	5-12-69	Town Point, Maryland	Hook & line	71	217	0.7	37.0
	N00501	3- 5-69	Kitty Hawk	5- 6-69	Reedville, Va.	---	59	111	0.7	38.0
	N00393	2-28-69	Kitty Hawk	6-20-69	Deale, Md.	Hook & line	112	144	0.9	39.0
	A00040	1-30-69	False Cape	4- 3-69	Patuxent Rv., Md.	Gill net	62	123	0.7	35.0
	N00122	2-27-69	Kitty Hawk-Currituck	7-21-69	Magothy Rv., Gibson's Is., Md.	Hook & line	144	181	0.7	37.0
	A00017	1-30-69	False Cape	8-22-70	Chesapeake Beach, Md.	Hook & line	569	130	0.9	41.0
1969-1970	A00270	12-16-69	Currituck-False Cape	---	Newport News, James V., Va.	Gill net	--	60	4.1	63.5
	A00130	12-17-69	Currituck-False Cape	---	Potomac Rv.	---	--	---	3.6	65.5
	A00582	2-13-70	Currituck-False Cape	2-21-70	Little Creek, Va.	Gill net	8	42	2.0	51.8
	A00583	2-13-70	Currituck-False Cape	3-10-70	Bowler's Wharf, Rappahannock Rv.Va.	Gill net	25	112	1.1	42.2
	A00187	12-16-69	Currituck-False Cape	3- 7-70	Bowler's Rock, Rappahannock Rv.,Va.	Gill net	81	112	1.8	47.5
	A00619	2-13-70	Currituck-Fales Cape	3-29-70	Pocomoke Sound, Va.	Gill net	44	87	1.1	43.0
	A00257	12-16-69	Currituck-False Cape	3-28-70	Colonial Beach, Potomac Rv., Va.	Gill net	102	152	1.8	48.8
	A00614	2-13-70	Currituck-False Cape	3-15-70	Tolchester Beach, Md.	Gill net	30	210	1.0	39.7
	A00598	2-13-70	Currituck-False Cape	3-17-70	Rock Hall, Md.	Gill net	32	202	1.6	45.2
	A00621	2-13-70	Currituck-False Cape	2-22-70	Miles Rv., Md.	Gill net	37	160	0.6	32.5
	A00145	12-18-69	Kitty Hawk-Currituck	3-26-70	Allmondsville, York Rv., Va.	Fyke net	77	100	4.5	79.0
	A00292	12-18-69	Kitty Hawk-Currituck	4- 1-70	Tappahannock, Rappahannock Rv., Va.	Gill net	104	139	2.7	54.8
	A00167	12-16-69	Currituck-False Cape	4-13-70	Dover, Choptank Rv., Md.	Gill net	118	182	0.9	45.5
	A00599	2-13-70	Currituck-False Cape	4-16-70	Senaca Cr., Md.	Gill net	62	215	0.8	35.5
	A00134	12-17-69	Currituck-False Cape	3-17-70	Poquoson Rv., Va.	Haul seine	90	92	2.0	51.8
	A00150	12-16-69	Currituck-False Cape	4-17-70	Grey Pt. Bridge, Rappahannock Rv.Va.	Gill net	122	85	1.6	48.2
	A00605	2-13-70	Currituck-False Cape	3-28-70	James Is., Md.	Hook & line	43	152	0.8	38.0
	A00498	2-1-70	Portsmouth Is.	2-29-70	Vienna, Nanticcke Rv., Md.	Gill net	87	252	13.2	94.5
	A00610	2-13-70	Currituck-False Cape	4-23-70	Wicomico Rv., Md.	Gill net	69	137	1.1	41.5
	A00596	2-13-70	Currituck-False Cape	3-26-70	Mouth of Patuxent Rv., Md.	Hook & line	41	142	1.9	50.8
	A00584	2-13-70	Currituck-False Cape	3-22-70	Warton Point, Md.	Gill net	37	209	1.7	47.4
	A00127	12-17-69	Currituck-False Cape	6-21-70	Mouth West Rv., Md.	Hook & line	186	175	2.7	60.5
	A00193	12-16-69	Currituck-False Cape	4- 5-70	James Rv. Br., Va.	Hook & line	110	63	2.3	53.5
	A00531	2- 1-70	Portsmouth Is.	7-20-70	Chesapeake Bridge, Md.	---	169	267	11.8	83.0
	A00477	2- 1-70	Portsmouth Is.	5-23-70	Thomas Pt. Lt., Md.	Hook & line	111	303	9.1	78.1

Table 18 (cont.)

Season	Tag no.	Date tagged	Location	Date recaptured	Location - CHESAPEAKE BAY	Gear	Days out	Net naut. miles trav.	Weight* (kg)	Fork length* (cm)
1970-1971	B00505	2-15-71	False Cape	3- 1-71	Poquoson Rv., Va.	Haul seine	14	47	5.0	73.0
	B00126	12- 9-70	Currituck Light	12-18-70	Chesapeake Bridge Tunnel, Va.	Hook & line	9	46	1.8	49.7
	A00991	12- 9-70	Currituck Light	2- 9-71	York Rv., Va.	Gill net	62	105	2.3	60.7
	B00503	2-15-71	Currituck-False Cape	3-10-71	Nansemond Rv., Va.	Gill net	22	70	1.8	50.0
	B00509	2-15-71	Currituck-False Cape	3- 6-71	Rappahannock Rv.,Bowler's Rock, Va.	Gill net	28	120	1.8	47.0
	B00160	12- 9-70	Currituck Light	4-15-71	Patuxent Rv.,Benedict, Md.	Gill net	127	170	3.2	64.1
	B00166	12- 9-70	Currituck Light	4-15-71	Choptank Rv., Md.	Gill net	127	210	2.7	54.4
	B00064	12- 9-70	Currituck Light	4-24-71	Dorchester Co.,Transquaking Rv.,Md.	Hook & line	136	170	2.7	59.5
	A00728	11-18-70	Currituck Light	4-15-71	Point of Shoals, James Rv., Va.	Gill net	146	66	5.4	77.0
	B00460	1-31-71	Oregon Inlet	4-26-71	Sandbridge Beach, Va.	Haul seine	40	85	2.3	55.0
	B00649	3-18-71	Hatteras Bight	5- 5-71	Jug's Cr.,Rappahannock Rv., Va.	Gill net	48	230	11.3	87.1
	B00114	12- 9-70	Currituck Light	5- 4-71	Crystal Beach, Md.	Gill net	146	220	1.8	53.0
	B00596	3-12-71	Oregon Inlet	7-18-71	Severn Rv., Md.	Hook & line	128	210	7.2	80.0
						Mean	66.6	130.8	2.0	48.0
					Location - NORTH OF CHESAPEAKE BAY					
1968-1969	N00115	2-27-69	Kitty Hawk-Currituck	5-10-69	Cape Cod, Mass.	Hook & line	72	547	0.7	37.0
	N00184	2-27-69	Kitty Hawk-Currituck	5- 2-69	Sakonnet Pt., Rhode Island	Trap	64	431	0.4	33.0
	N00128	2-27-69	Kitty Hawk-Currituck	5-26-69	Cape Cod, Mass.	Hook & line	88	547	0.9	40.0
	N00197	2-27-69	Kitty Hawk-Currituck	5-24-69	Westport Harbor, Mass.	Hook & line	86	439	0.9	40.0
	A00014	12-12-68	Ocracoke-Hatteras Inlet	6-10-70	Nantucket Is., Mass.	Hook & line	545	523	12.7	9910
1969-1970	A00515	2- 1-70	Portsmouth Is.	5-24-70	Nauset Beach, Chatham, Mass.	Hook & line	112	600	7.7	87.7
	A00495	2- 1-70	Portsmouth Is.	6- 3-70	Naragansett Bay, Rhode Is.	Hook & line	122	527	18.1	103.0
	A00346	1-17-70	Hatteras Inlet	6- 2-70	Cuttyhaunk, Mass.	Hook & line	121	565	11.8	91.5
	A00435	2- 1-70	Portsmouth Is.	6-10-70	Amagansett L.I., N.Y.	Haul seine	129	503	13.6	96.0
	A00052	12-16-69	Currituck-False Cape	6-20-70	Cape Cod Bay, N. Truro, Mass.	Hook & line	191	635	10.0	82.2
	A00362	1-20-70	Hatteras Inlet	6-17-70	Twin Lights, Atlantic Highlands NJ	Hook & line	148	340	17.2	112.0
	A00315	1-17-70	Hatteras Inlet	7- 3-70	Cape Cod Bay, Mass.	Hook & line	167	675	8.2	84.0
	A00511	2- 1-70	Portsmouth Is.	5-29-70	Pleasant Bay, Chatham, Mass.	Hook & line	118	600	11.3	90.0
	A00564	2-11-70	Core Banks, Drum In.	7- 6-70	Sandy Hook, N J.	Hook & line	145	315	15.9	102.0

Table 18 (cont.)

Season	Tag no.	Date tagged	Location	Date recap-tured	Location - NORTH OF CHESAPEAKE BAY	Gear	Days out	Net naut. miles trav.	Weight* (kg)	Fork length* (cm)
	A00417	2- 1-70	Portsmouth Is.	7- 3-70	Sandy Hook, N.J.	Hook & line	152	315	15.9	94.0
	A00530	2- 1-70	Portsmouth Is.	6-15-70	Pleasant Bay, Chatham, Mass.	Hook & line	134	600	10.9	88.5
	A00418	2- 1-70	Portsmouth Is.	5-15-70	Thames Rv., Norwich, Conn.	Hook & line	103	491	15.4	99.0
	A00394	2- 1-70	Portsmouth Is.	7-17-70	Long Island Sound, Rye, N.Y.	Hook & line	166	365	13.6	98.0
	A00419	2- 1-70	Portsmouth Is.	7-20-70	Amagansett, Long Island, N.Y.	Haul seine	169	503	22.2	110.0
	A00332	1-17-70	Hatteras Inlet	8-22-70	Pleasant Bay, Chatham, Mass	Hook & line	217	600	13.2	97.0
	A00532	2- 1-70	Portsmouth Is.	---	Narragansett Bay, Rhode Is.	Hook & line	---	500	14.5	96.0
	A00623	2-13-70	Currituck-False Cape	9 - 70	Camp Ellis, Saco Rv., Maine	Hook & line	---	580	6.3	74.0
1970-1971	B00244	12-15-70	Oregon Inlet	5-10-71	Long Island, N.Y.	Haul seine	146	380	5.0	56.2
	A00773	11-21-70	Kitty Hawk	5-18-71	2 mi. off Cape May In., N.J.	Trawl	178	225	10.9	95.0
	B00144	12- 9-70	Currituck Light	6- 7-71	Montauk Point, L.I., N.Y.	Hook & line	180	400	3.6	66.1
	B00174	12- 9-70	Currituck Light	6- 7-71	Elizabeth Is., Woods Hole, Mass.	Hook & line	180	500	5.4	77.4
	B00150	12- 9-70	Currituck Light	6- 5-71	Cape Cod Bay, Mass.	Hook & line	178	600	1.8	54.8
	B00545	3-12-71	Oregon Inlet	5-25-71	Cape Cod, Popponessett Bch., Mass.	Hook & line	74	600	2.3	53.6
	B00466	1-31-71	Oregon Inlet	6- 8-71	Mattapoisette Rv., Mass.	Hook & line	128	550	2.7	50.0
	B00083	12- 9-70	Currituck Light	6-18-71	Shinnecock, In., L.I.	Hook & line	191	365	4.1	75.1
	B00530	3-12-71	Oregon Inlet	6-18-71	Barnegat Inlet, N. J.	Hook & line	98	260	7.2	77.5
	A00719	11-18-70	Currituck Light	6-15-71	Duxbury, Mass.	Hook & line	209	550	4.1	68.9
	B00650	3-18-71	Hatteras Bight	7- 3-71	Long Beach, N.Y.	Hook & line	107	400	10.9	94.0
	A00765	11-20-70	Kitty Hawk-Currituck	7- 1-71	Cape Cod Bay, Barnstable, Mass.	Hook & line	223	605	10.4	94.8
	B00407	1-14-71	Ocracoke Inlet	7- 1-71	Barnestable, Mass.	Hook & line	142	710	12.2	93.5
	B00016	12- 9-70	Currituck Light	6- 6-71	Cape Cod Bay, Falmouth, Mass.	Hook & line	179	485	4.1	72.0
	A00788	11-21-70	Kitty Hawk-Currituck	6-12-71	Monmouth Beach, N.J.	Hook & line	203	305	10.4	97.5
	B00636	3-18-71	Hatteras Bight	7- 7-71	Barnstable, Mass.	Hook & line	111	700	10.9	92.0
	B00106	12- 9-70	Currituck Light	7- 7-71	Coney Island, N.Y.	Hook & line	210	305	3.2	65.4
	B00074	12- 9-70	Currituck Light	5-23-71	Warich, Rhode Island	Hook & line	165	450	5.0	74.8
	B00011	12- 9-70	Currituck Ligh	7-16-71	New London, L.I., N.Y.	Hook & line	219	425	7.2	84.9
	B00369	1-13-71	Hatteras Inlet	7-17-71	Barnstable, Mass.	Hook & line	185	625	11.8	91.0
	B00508	2-15-71	Currituck-False Cape	7-21-71	Long Is. Sound, Mamaconeck, N.Y.	Hook & line	156	340	3.2	61.0
	A00701	11-18-70	Currituck Light	8- 5-71	Montauk Point, L.I., N.Y.	Hook & line	260	400	11.3	97.9
	A00927	12- 9-70	Kitty Hawk-Currituck	8-12-71	Cape Cod Bay, Rock Harbor, Mass.	Hook & line	246	590	10.4	95.5
	B00132	12- 9-70	Currituck Light	8- 7-71	Cape Cod Bay, Billingsgate Is.Mass.	Hook & line	241	585	5.9	78.1
	B00576	3-12-71	Oregon Inlet	7-19-71	Plum Gut Is. L.I., N.Y.	Hook & line	129	420	4.5	68.7
	A00712	11-18-70	Currituck Light	7-26-71	Long Is. Sound, off Hamford, Conn,	Hook & line	250	450	10.9	98.0

Table 18 (cont.)

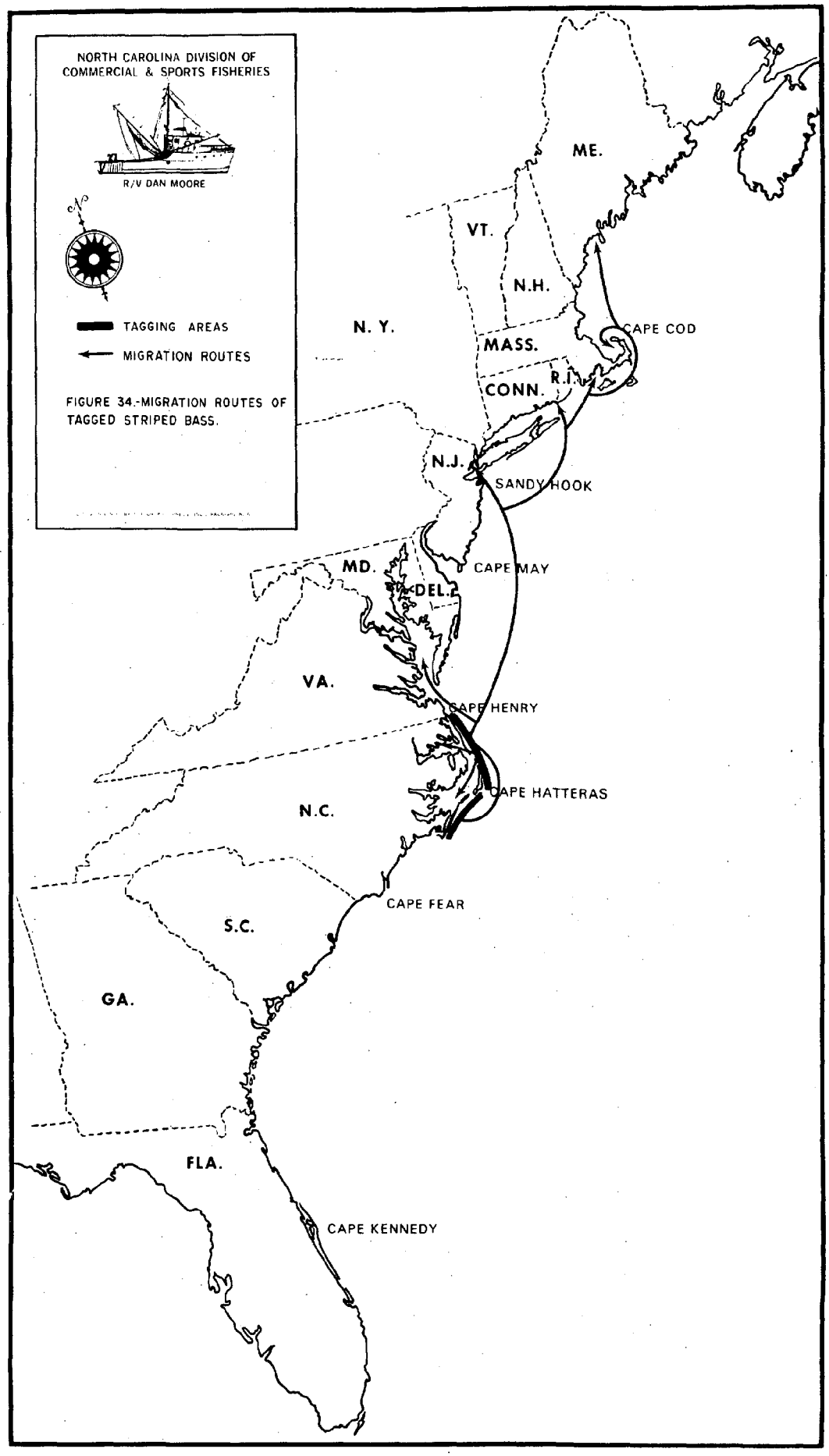
Season	Tag no.	Date tagged	Location	Date recap-tured	Location - NORTH OF CHESAPEAKE BAY	Gear	Days out	Net naut. miles trav	Weight* (kg)	Fork length* (cm)
	B00135	12- 9-70	Currituck Light	8- 6-71	Woods Hole, Mass.	Hook & line	240	475	4.1	69.9
	B00014	12- 9-70	Currituck Light	9-18-71	Cape Cod, Billingsgate Shaols, Mass.	Hook & line	283	585	5.9	74.5
	B00365	1-13-71	Hatteras Inlet	---	Montauk Point, L.I., N.Y.	Hook & line	---	510	9.5	88.0
	B00613	3-14-71	Oregon Inlet-Kitty Hawk	9-23-71	Shrewsbury Rv.Br., Highlands, N.J.	Hook & line	193	313	5.9	74.0
	B00480	1-31-71	Oregon Inlet	8-21-71	Chatham Harbor, Mass.	Hook & line	202	517	2.3	52.5
	B00571	3-12-71	Oregon Inlet	10-13-71	Montauk Point, L.I., N.Y.	Hook & line	215	400	5.0	71.0
	A00830	12- 3-70	Currituck Light	10-15-71	Sakonnet Point, Rhode Island	Hook & line	316	388	10.0	95.5
						Mean	174.7	482.0	8.4	80.2

* Weight and length when tagged

grounds for the migratory segment of the Atlantic coast striped bass population. Three main groups of fish appear to congregate off the North Carolina coast during the period November to March: striped bass which enter Albemarle and Pamlico Sounds, North Carolina (apparently mostly small fish), fish from Chesapeake Bay (mixed sizes), and predominately large striped bass which spend the summer from New Jersey northward (Figure 34).

The tagging data summarized in Table 17 requires some explanation. Returns from the 1968-1969 taggings differ somewhat from the 1969-1970 and 1970-1971 programs. During the first segment, tagging efforts were confined along a relatively small portion of the coast (Oregon Inlet to the North Carolina-Virginia border) and were concentrated during February 1969. During the other two segments, tagging efforts covered the entire North Carolina coast and extended from November through March each segment. The first segment's work, therefore, did not give an adequate sample of the striped bass over-wintering along the North Carolina coast. The low return rate from North Carolina suggests that in spite of the large catches made by North Carolina fishermen, particularly beach seiners and ocean trawlers, these fishermen have had little effect on the over-wintering striped bass population. The fish, in fact, may be under-harvested by North Carolina fishermen. The great majority of striped bass caught by the North Carolina oceanic haul seine and trawl fisheries during the 1968-1969, 1969-1970, and 1970-1971 segments were small fish, no more than three or four years old. Prior to this period, the oceanic catch was quite small and was dominated by large fish. In addition, prior to catching them during this study, large striped bass were rarely encountered in the ocean south of Cape Hatteras.

It is believed that the tag return data do not give a true picture of the movements of large striped bass. During the study, 373 fish weighing 10 kilograms or more were tagged. Of the 35 fish of this size group recaptured, 26 (74%)


NORTH CAROLINA DIVISION OF
COMMERCIAL & SPORTS FISHERIES
R/V DAN MOORE
TAGGING AREAS
MIGRATION ROUTES
FIGURE 34.-MIGRATION ROUTES OF TAGGED STRIPED BASS.
ME.
VT.
N.H.
N. Y.
MASS.
CONN.
R.I.
CAPE COD
N.J.
SANDY HOOK
MD.
DEL.
CAPE MAY
VA.
CAPE HENRY
N.C.
CAPE HATTERAS
CAPE FEAR
S.C.
GA.
FLA.
CAPE KENNEDY

were from north of Chesapeake Bay. All of these recaptured fish were taken during the late spring and summer, after the spawning season. Where these fish spawned is not clear. The gill nets used to capture striped bass in the inshore waters of North Carolina are designed to catch fish 2-5 years old, and fish greater than 10 kilograms are rarely captured. Therefore, the actual distribution of these large fish in the inland waters of North Carolina is unknown except on the Roanoke River spawning grounds at Weldon, North Carolina. Most fishermen in Virginia also concentrate on smaller fish. A large fish (11.3 kg) from Rappahanock River, Virginia, (5 May 1971) was probably on its way to or from the spawning grounds. In Maryland it is illegal to keep striped bass over 15 pounds in weight during April and May (the spawning season). The presence of these large fish, therefore, goes largely undetected in the inshore waters of North Carolina, Virginia, and Maryland during the spawning season.

The northern movement of large fish to New England was in basic agreement with Merriman (1941), although he believed the southernmost point of the migration route was Chesapeake Bay. He stated further that striped bass found south of Cape Hatteras did not intermix with northern stocks. However, during this study, striped bass tagged south of Cape Hatteras were recaptured in Chesapeake Bay north to Massachusetts.

Vladykov and Wallace (1952) suggested that striped bass from North Carolina sounds and Chesapeake Bay do not intermingle, but large fish from both areas may contribute to the mid-Atlantic and New England populations of striped bass. They made no comments on whether or not fish overwintering on the North Carolina coast might enter Chesapeake Bay. As in this study, Chopoton and Sykes (1961) found that striped bass tagged on the North Carolina coast entered Albemarle Sound and Chesapeake Bay. A few of their fish were also caught along the mid-Atlantic and New England coasts.

In contrast to the results obtained during the first segment when haul seines and gill nets captured similar numbers of tagged striped bass, gill nets and sports fishermen were responsible for more than 50 percent of the recaptures during the second and third segments (Tables 19, 20, and 21).

Mortality

Striped Bass

Basic assumptions involved in the estimation of mortality are: (1) No loss of tagged releases caused by handling and after-effects of the tag; (2) either no loss of recaptured striped bass because of failure of fishermen to return them, or the ratio of undetected to detected recaptures remains essentially constant during each experiment; and (3) all tagged striped bass were available to the fishery.

Only those striped bass that appeared in good condition and displayed no signs of distress after tagging were released in the studies presented herein.

For the purpose of estimating mortality, the tagged or experimental populations are assumed to react as their parent groups. There is evidence which indicated large striped bass (10 kg or more) may go largely undetected in inland waters of North Carolina, Virginia, and Maryland. Generally, when tagged fish become unavailable to the fishery, the result is an increase in the total and natural mortality estimates. If these fish remain unavilable to the fishery, they are, for all practical purposes, lost to natural causes and should be considered as a valid part of natural mortality estimates when applying management techniques established as a result of these estimates.

The loss of recaptured fish because of failure of fishermen to return them is believed negligible. The incentive to return tags was high and cooperation with commercial and sports fishermen was excellent. It was assumed that the ratio of undetected to detected recaptures did not change during the experiments.

Table 19.—Fishing gear used to recapture striped bass tagged offshore North Carolina, 1968 - 1969

Fishing gear	Major Recapture Areas: Inside N. C. No.	Inside N. C. Percent	Offshore N. C. No.	Offshore N. C. Percent	Chesapeake Bay No.	Chesapeake Bay Percent	North of Chesapeake Bay No.	North of Chesapeake Bay Percent	Totals No.	Totals Percent
Gill net	2	50.0	0	0.0	10	25.0	0	0.0	12	22.2
Haul seine	1	25.0	1	20.0	13	32.5	0	0.0	15	27.8
Trawl	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Pound net	1	25.0	0	0.0	6	15.0	0	0.0	7	13.0
Fish trap	0	0.0	0	0.0	0	0.0	1	20.0	1	1.8
Sport	0	0.0	0	0.0	5	12.5	4	80.0	9	16.7
Unknown	0	0.0	4	80.0	6	15.0	0	0.0	10	18.5
	4		5		40		5		54	

Table 20.—Fishing gear used to recapture striped bass tagged offshore North Carolina 1969 - 1970

Fishing gear	Major Recapture Areas: Inside N. C. No.	Inside N. C. Percent	Offshore N. C. No.	Offshore N. C. Percent	Chesapeake Bay No.	Chesapeake Bay Percent	North of Chesapeake Bay No.	North of Chesapeake Bay Percent	Totals No.	Totals Percent
Gill net	11	68.8	0	0.0	14	56.0	0	0.0	25	38.5
Haul seine	5	31.2	5	71.4	1	4.0	2	11.8	13	20.0
Trawl	0	0.0	2	28.6	0	0.0	0	0.0	2	3.1
Fyke net	0	0.0	0	0.0	1	4.0	0	0.0	1	1.5
Sport	0	0.0	0	0.0	4	16.0	15	88.2	19	29.2
Unknown	0	0.0	0	0.0	5	20.0	0	0.0	5	7.7
	16		7		25		17		65	

Table 21.--Fishing gear used to recapture striped bass tagged offshore North Carolina, 1970 - 1971, as of 1 November 1971

Fishing gear	Major Recapture Areas								Totals	
	Inside N. C.		Offshore N. C.		Chesapeake Bay		North of Chesapeake Bay			
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Gill net	13	68.4	0	0.0	8	57.1	0	0.0	21	26.6
Haul seine	0	0.0	10	76.9	1	7.1	1	3.0	12	15.2
Trawl	1	5.3	0	0.0	0	0.0	1	3.0	2	2.5
Crab dredge	0	0.0	0	0.0	1	7.1	0	0.0	1	1.3
Pound net	1	5.3	0	0.0	0	0.0	0	0.0	1	1.3
Sport fishing	1	5.3	1	7.7	4	28.6	30	90.9	36	45.6
Unknown	3	15.7	2	15.4	0	0.0	1	3.0	6	7.5
	19		13		14		33		79	

Total mortality (Z = F+X = fishing plus natural mortality) estimates were obtained by fitting linear regressions to the natural logarithms of monthly recaptures, adjusted for unequal fishing effort, plotted against monthly (recapture) time periods (Beverton and Holt, 1957). The slope of the regression is the instantaneous total mortality rate. Fishing effort was assumed to be equal because no data were available.

Monthly instantaneous total mortality rates (Z) calculated for striped bass populations included in this study are presented in Table 22. Presented also are the monthly rates of reduction, expressed in percentages, for the seasonal experimental populations. The mean total reduction per month for the 1968 through 1971 fishing seasons was 24.3 percent. The mean reduction per month due to fishing was 3.6 percent.

A search of the literature revealed no sources of striped bass mortality information utilizing tag-recapture data analyzed by the method used herein and as outlined by Beverton and Holt (1957). Ideally, mortality estimates utilizing this method would have been obtained by fitting linear regressions to the natural logarithm of annual recaptures, wherein annual recapture data would be desired over a period of at least three years following annual tagging periods.

Hassler et al (1966 and 1967) present estimated overall exploitation rates for striped bass in the Albemarle Sound area of North Carolina as 26 percent and 24.5 percent respectively, for the years 1965 and 1966. These exploitation rates are actually annual percentages of tag returns and do not account for recaptured fish from which tags were not returned. The exploitation rates presented should then be considered the absolute minimum.

The method outlined by Beverton and Holt (1957) and used herein assumes no loss of recaptured tags, or that the ratio of lost to recovered recaptured tags remains essentially constant over the selected time periods (months) during each experiment. If this is a valid assumption, the slope of the regression

Table 22.—Instantaneous and monthly mortality rates calculated from striped bass tagging data, offshore North Carolina 1968 - 1971

Year period	Months released	Instantaneous Mortality rates Total (Z)	Fishing (F)	Other (X)	Monthly Mortality rates (percent) Total ($1-e^{-Z}$)	Fishing ($1-e^{-X}$)	Other ($1-e^{-X}$)
1968-1969	December-March	0.347	0.070	0.276	29.5	6.8	24.4
1969-1970	December-February	0.294	0.028	0.276	25.2	3.0	24.4
1970-1971	November-March	0.186	0.009	0.178	17.3	1.0	16.5
Monthly means		0.278	0.036	0.243	24.3	3.6	21.8

from which the harvest rate or monthly fishing mortality rate is determined would not change.

The exploitation rate, based on mean recapture data presented in Table 17, is 11.2 percent which is considered the absolute minimum harvest rate. The mean monthly fishing mortality rate presented in Table 22 is 3.6 percent and does not take into account unequal fishing effort that probably existed over the months involved. If the monthly fishing effort was known and the recapture date adjusted to a constant or equal monthly effort, the slope of the regression would change and result in at least slightly different mortality estimates.

The mean monthly fishing mortality rate of 3.6 percent was projected to represent an annual harvest rate (Beverton and Holt, 1957). The calculated annual fishing mortality rate for striped bass tagged in the ocean off North Carolina and recaptured from North Carolina to Maine (both oceanic and estuarine) was 35 percent. This disagrees with exploitation rates and indicates a much higher and probably more valid harvest than is indicated by the percentage of recaptures.

The mean monthly natural (other) mortality rate presented in Table 22 is presumed to be high because tagged fish still at large are included in the estimate as natural losses.

Biological Studies

Data from 290 striped bass were taken for length, weight and age analyses. In addition, 152 were examined for food habits and 35 for fecundity.

Data from 202 American shad were taken for length, sex, weight, and age analyses of which 60 (45 adults and 15 juveniles) were examined for food habits and 43 for fecundity.

A sample of 362 adult blueback herring and 72 alewife were examined for length, weight, age and sex. An additional 16 blueback herring and 11 alewife were analyzed for food habits.

From 1 March 1971 through 4 May 1971, 542 adult blueback herring and 387 alewife from Chowan River at Tunis were examined for length, weight, age and sex to determine if, in fact, a relationship exists between fish caught in the ocean off North Carolina and those caught in the Chowan River, North Carolina.

Food Habits

Striped Bass - During the first segment, stomach contents of 50 striped bass (28 to 82 cm) were analyzed. Sterling and Godwin (1970) reported that the contents of 41 (82%) of the 50 dissected stomachs were unidentifiable. The silverside (Menidia menidia) was found in two specimens, and the sand shrimp (Cragon septemspinosa) in seven.

During the second segment, 50 striped bass (42.4 - 109.4 cm) were examined. Only seven (14%) of the 50 striped bass stomachs examined were empty. All the others contained identifiable fish or unidentifiable fish remains. No invertebrates were found. Unidentified fish remains (mostly vertebral columns) were found in 74 percent of the stomachs. The most frequently occurring identifiable fish were the sciaenids Bairdeilla chrysura (in 24% of the stomachs) and Cynoscion regalis (in 18% of the stomachs). The most frequently occurring identifiable food item by number, weight, and volume was weakfish, Cynoscion regalis. Results of the 1969-1970 stomach analyses are summarized in Table 23.

During the third or final segment, 52 additional striped bass (45.5 to 111.0 cm) were analyzed. These stomachs were dissected aboard ship, while still fresh, to make identifications of smaller invertebrates and fish which might otherwise deteriorate after being preserved in formalin. Eleven (21.2%) of these striped bass stomachs were empty. All others contained identifiable fish, or unidentifiable fish remains or invertebrates. Unidentified fish remains (mostly vertebral columns) were found in 28.8 percent of the stomachs. The most frequently occurring identifiable fish were Brevoortia tyrannus (in 19.2% of the

Table 23.--Stomach analyses of 50 striped bass caught on the North Carolina coast, February and March, 1970

Food item	No. stomachs	%	No. organisms	%	Tot. wt. (g)	%	Mean wt. (g)	Tot. vol. (ml)	%	Mean vol. (ml)
Cynoscion regalis	9	18	18	11.3	2585	28.4	143.6	2385	29.4	132.5
Cynoscion nebulosus	1	2	1	0.6	115	1.2	115.0	108	1.3	108.0
Leiostomus xanthurus	5	10	8	5.0	443	4.8	54.1	369	4.6	46.1
Bairdiella chrysura	12	24	15	9.4	803	8.8	53.5	719	8.8	47.9
Brevoortia tyrannus	1	2	1	0.6	134	1.5	134.0	115	1.4	115.0
Scomber sp.	1	2	2	1.2	114	1.2	57.0	100	1.2	50.0
Anchoa hepsetus	2	4	12	7.5	18	0.2	1.5	15	0.2	1.3
Unidentified fish	37	74	103	64.4	4911	53.9	47.7	4319	53.1	41.9
Empty	7	14								
			160	100	9113	100		8130	100	

stomachs) and Anchoa hepsetus (in 15.4% of the stomachs). The results of the 1970-1971 stomach analyses are summarized in Table 24.

Correlating stomach contents of striped bass collected at a given station with other species collected at the same station indicated that fish of the family Scienanidae (1969-1970) and Brevoortia tyrannus and Anchoa hepsetus (1970-1971) were the most available food items as well as the most frequently encountered food items in the stomachs.

Pearson (1938:839) states that the striped bass is "carnivorous, predacious, and an active feeder," consuming a wide variety of fishes and invertebrates. Other workers such as Smith (1907), Bigelow and Schroeder (1953), Merriman (1937) and Hollis (1952) reported a wide variety of organisms from striped bass stomachs indicating that the striped bass is an opportunistic feeder. All of the stomachs examined during the present study were from fish captured during the winter, suggesting that striped bass (particularly large striped bass) remain active feeders during the colder months.

American Shad - Analyses of the contents of 19 American shad stomachs, during the second segment, are shown in Table 25. Of the four adults examined, two contained unidentified flesh and two were empty. Only three of the 15 juveniles examined had empty stomachs. All the others contained one to five Anchoa hepsetus. Occurrence of these anchovies, especially in the stomachs of juvenile shad (87-141mm) is of interest. Various authors have indicated that, while adult shad may sometimes eat small fish, juveniles restrict their diet to various planktonic organisms and occasional benthic invertebrates (Bigelow and Schroeder, 1953; Leim and Scott, 1966).

During the third segment of this study gross examination was made of the stomach contents of 41 adult American shad from 42.0 to 50.6 cm in fork length. These fish were captured 12 and 13 March 1971, in the ocean off Oregon Inlet, North Carolina. All of the 41 stomachs contained food. Unidentifiable fish

Table 24.—Stomach analyses of 52 striped bass caught off the North Carolina coast, 1970 - 1971

Food item	Number stomachs	Percent	Number organisms	Percent
Brevoortia tyrannus	10	19.2	15	5.5
Etrumeus teres	2	3.8	3	1.1
Anchoa hepsetus	8	15.4	208	76.8
Strongylura sp.	3	5.8	4	1.5
Syngnathus sp.	1	1.9	3	1.1
Bairdiella chrysura	2	3.8	2	0.7
Cynoscion regalis	5	9.6	5	1.8
Ammodytes americanus	1	1.9	1	0.4
Peprilus triacanthus	2	3.8	2	0.7
Hepatus epheliticus	1	1.9	1	0.4
Portunis sp.	1	1.9	1	0.4
Callinectes sapidus	2	3.8	2	0.7
Aegathoa oculata	1	1.9	1	0.4
Loligo sp.	1	1.9	1	0.4
Unidentified fish	15	28.8	22	8.1
Empty	11	21.2		
			271	100

Table 25.—Stomach analyses of 19 American shad caught off the North Carolina coast, winter 1969 - 1970

Food item	No. of stomachs	Percent	No. of organisms	Percent	Total weight (g)	Percent
Anchoa hepsetus	12	63.1	27	93.1	15.8	98.1
Unidentified flesh	2	10.5	2	6.9	0.3	1.9
Empty	5	26.3				
			29		16.1	

remains (mostly vertebral columns and gill arches) and identifiable fish were found in 39 (95.1%) of the stomachs. Nine (22%) contained from one to 12 Anchoa hepsetus from 40 to 70 mm in length. All the stomachs contained some form of zooplankton which consisted of various species of amphipods, copepods, isopods, cumaceans, decapod larvae, and bivalves. The majority were under five mm in size. Twenty-eight (68.3%) also contained various forms of phytoplankton.

The data, although based on fish collected in salt water, disagree with the theory put forth by Atkinson (1951). He suggested that the stomachs of American shad found in fresh water were devoid of food because the potential food items in fresh water (zooplankton) were generally of a size too small to be retained by the shad's filter-feeding system. Atkinson believed that organisms 5mm in size were too small for American shad to capture. The present data indicate that shad not only are capable of feeding on organisms under 5 millimeters in size, but on occasion may feed extensively on organisms of this size class.

In addition, the occurrence of unidentifiable fish remains and identifiable fish in 95.1 percent of the adult shad stomachs is of interest. Various authors indicated adult shad may sometimes eat fish but are primarily plankton feeders and fishes make up a very small part of their food (Bigelow and Schroeder, 1953; Leim and Scott, 1966). The present data indicate adult shad not only eat fish, but on occasion eat fish to the extent fish could be considered a major food item.

Blueback Herring - Gross examination was performed on the stomach contents of 16 adult blueback herring from 16.7 to 24.1 cm in fork length. These fish were captured 15 February 1971 approximately 15 miles east of Currituck Beach, North Carolina. All 16 stomachs contained food. No fish or fish remains were present in the stomachs. All stomachs contained zooplankton consisting of various species of amphipods, copepods, isopods, cumaceans, mysids, and decapod larvae.

Alewife - Gross examination was also performed on the stomach contents of 11 adult alewife from 21.5 to 28.3 cm in fork length. These fish were captured in the same sample as the blueback herring above. Only one of the eleven stomachs examined was empty. Unidentifiable fish remains (mostly vertebral columns) were found in four (36.4%) of the stomachs. Ten of the stomachs contained some form of zooplankton which consisted of various species of amphipods, copepods, isopods, cumaceans, mysids, sagitta, and decapod larvae.

Fecundity

Striped Bass - Fecundity was estimated for 35 female striped bass ranging from 77.0 to 111.0 cm fork length, and from 7 to 13 years of age. Estimated fecundities as well as other data for each fish are shown in Table 26.

As a check on the method of calculating fecundity (already described, see "Methods"), fecundity was also determined by calculating the mean number of ova per gram for each fish, then multiplying that value by the total weight of the two ovaries. When the fecundity values obtained by the two methods were compared, no significant difference was found (paired comparisons d.f. = 34, $t = 0.86$, and $P = .4$).

Mean fecundity was 2,462,372, while the range was from 614,243 for a seven-year old fish to 4,057,059 for a ten-year old specimen (Table 27). Jackson and Tiller (1952) examined striped bass in Chesapeake Bay and found fecundities ranging from 856,000 to 4,536,000 for fish from 6 to 14 years of age. They found linear relationships and high correlation ($>.9$) between fecundity and length, weight, and age. Lewis and Bonner (1966) also found linear relationships between fecundity and length and weight through age 13. They also found a relationship between fecundity and age up to nine years.

In this study, highly significant linear relationships were also found between fecundity and fork length, weight, and age, with T values of 9.26**, 9.73**, and 5.05** respectively (Figures 35, 36, and 37).

Table 26.—Age, fork length, weight and estimated fecundity of 35 striped bass caught off the North Carolina coast, January 1970 - March 1971 (SB-9-3, SB-5-3, SB-7-3, SB-6-3, SB-8-3 captured in November 1970)

Specimen number	Fork length (cm)	Weight (kg)	Age	Right ovary		Est. fecundity right ovary	Left ovary		Est. fecundity left ovary	Total est. fecundity
				Weight	Ova/g		Weight	Ova/g		
SB-29-2	77.0	5.4	7	77	4,169	321,013	70	4,189	293,230	614,243
SB-21-2	80.0	7.7	8	422	2,518	1,062,596	445	2,605	1,159,225	2,221,821
SB-28-2	85.0	7.7	8	165	3,086	509,190	176	3,040	535,040	1,044,230
SB-33-2	85.0	8.2	8	394	2,967	1,168,998	351	2,739	961,389	2,130,387
*SB- 9-3	84.7	7.3	8	59	10,962	646,758	67	11,527	722,309	1,416,360
SB- 1-2	89.5	10.0	9	288	3,113	896,544	292	3,320	969,440	1,865,982
SB- 3-2	90.0	10.9	9	322	3,582	1,153,404	338	3,863	1,305,694	2,459,098
SB- 7-2	88.0	10.4	9	339	1,627	551,553	442	1,730	764,660	1,316,213
SB-14-2	82.0	7.7	9	282	2,436	686,952	304	2,603	791,312	1,478,264
SB-23-2	96.0	13.6	9	552	3,259	1,798,968	623	3,077	1,916,971	3,715,939
SB-25-2	88.0	9.1	9	78	5,723	446,394	102	6,089	621,078	1,067,472
SB-31-2	85.0	8.6	9	587	1,433	841,171	666	1,386	923,076	1,764,247
SB-39-2	90.0	8.6	9	363	2,642	959,046	437	3,099	1,354,263	2,313,309
SB- 1-3	89.3	9.5	9	148	8,010	1,185,480	157	6,564	1,030,548	2,216,390
*SB -5-3	84.7	7.3	9	33	15,416	508,728	34	18,585	631,890	1,133,383
*SB- 7-3	96.0	9.9	9	123	10,781	1,326,063	121	11,618	1,405,778	2,730,077
SB-24-3	88.7	9.5	9	201	6,415	1,289,415	197	6,331	1,247,207	2,536,622
SB-39-3	98.1	12.7	9	247	5,218	1,288,846	286	4,936	1,411,696	2,700,542
SB- 2-2	89.2	10.4	10	267	2,898	773,766	388	3,616	1,403,008	1,995,974
SB-12-2	109.0	19.0	10	613	1,974	1,210,062	1,213	2,309	2,800,817	4,057,059
SB-43-2	100.0	16.3	10	997	1,759	1,753,723	1,126	1,689	1,901,814	3,655,537
*SB- 6-3	93.0	9.0	10	90	12,682	1,141,380	90	12,435	1,119,150	2,258,365
SB- 4-2	103.0	15.4	11	631	2,054	1,296,074	682	2,628	1,792,296	3,088,370
SB- 8-2	96.0	13.6	11	822	1,648	1,354,656	848	1,705	1,445,840	2,800,496
SB-17-2	101.0	19.0	11	929	1,496	1,389,784	1,204	1,620	1,950,480	3,340,264
SB-35-2	100.0	14.5	11	942	1,480	1,394,160	989	1,425	1,409,325	2,803,485
SB-42-3	108.0	18.6	11	927	2,052	1,902,204	1,147	1,686	1,933,842	3,836,046
SB- 3-3	111.0	16.3	11	333	5,331	1,775,223	395	5,408	2,136,160	3,911,439
SB- 4-3	94.5	9.9	11	146	8,330	1,216,180	152	6,930	1,053,360	2,269,985
*SB- 8-3	95.0	9.9	11	88	10,865	956,120	104	11,690	1,215,760	2,167,324
SB-10-3	102.0	10.9	11	186	6,629	1,232,994	197	5,475	1,078,575	2,311,322
SB-11-3	91.7	10.0	11	207	6,698	1,386,486	202	6,781	1,369,762	2,756,248
SB-42-3	95.0	12.2	12	417	3,430	1,430,310	497	3,771	1,874,187	3,304,497
SB-43-3	98.7	12.7	12	337	5,514	1,858,218	326	5,070	1,652,820	3,511,038
SB-22-3	101.8	14.5	13	345	4,714	1,626,330	404	4,368	1,764,672	3,391,002

Table 27.—Mean fecundity and range for each age group of 35 striped bass from offshore North Carolina, January 1970 - March 1971

Age	Number of fish	Mean fecundity	Fecundity range
7	1	614,243	614,243
8	4	1,703,200	1,044,230 - 2,221,821
9	13	2,099,811	1,067,472 - 3,715,939
10	4	2,991,733	1,995,974 - 4,057,059
11	10	2,928,498	2,167,324 - 3,911,439
12	2	3,407,767	3,304,497 - 3,511,038
13	1	3,391,002	3,391,002
	35	2,462,372	614,243 - 4,057,059

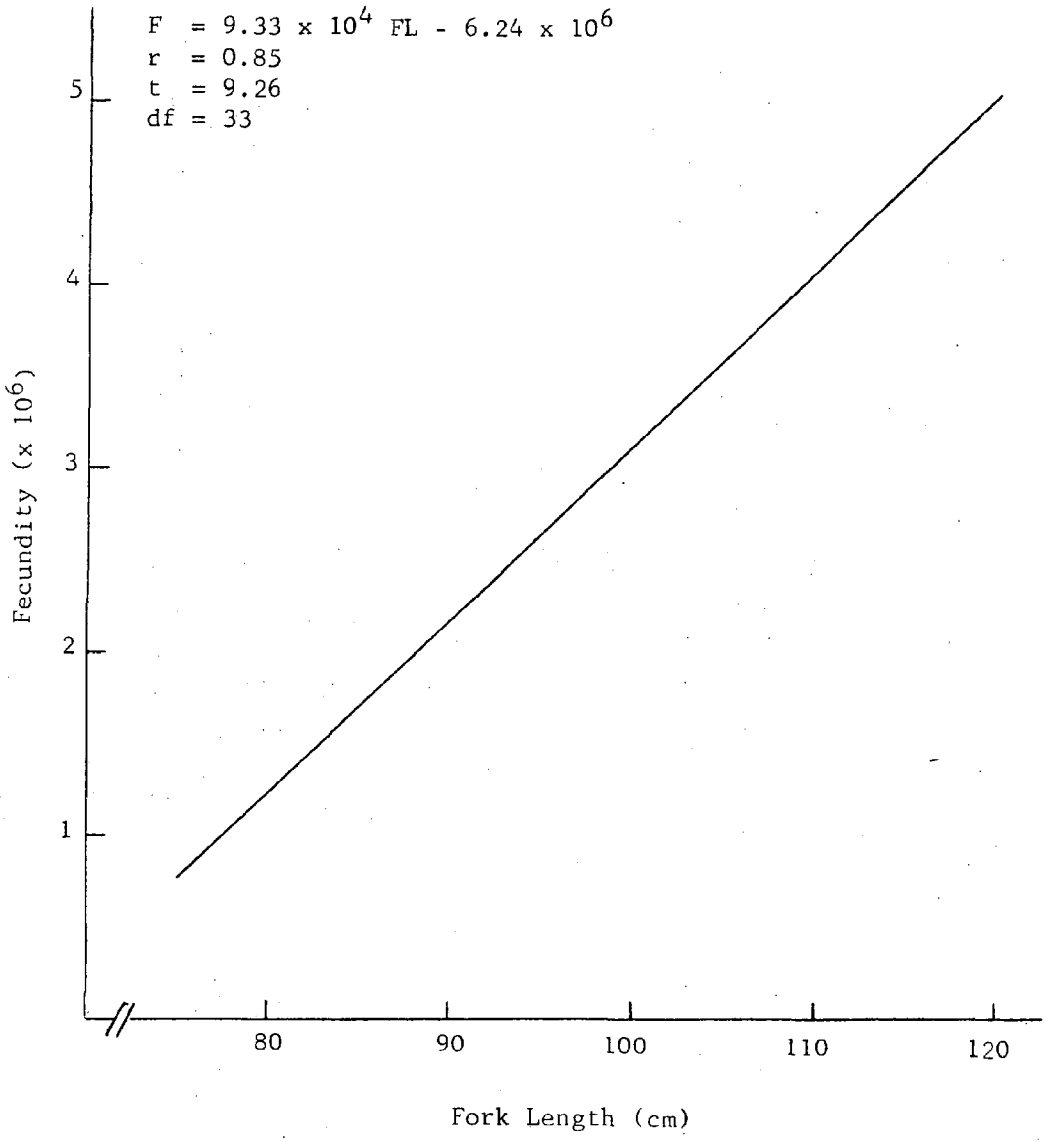


Figure 35.--Fecundity - fork length relationship for 35 striped bass, offshore North Carolina, 1969 - 1971.

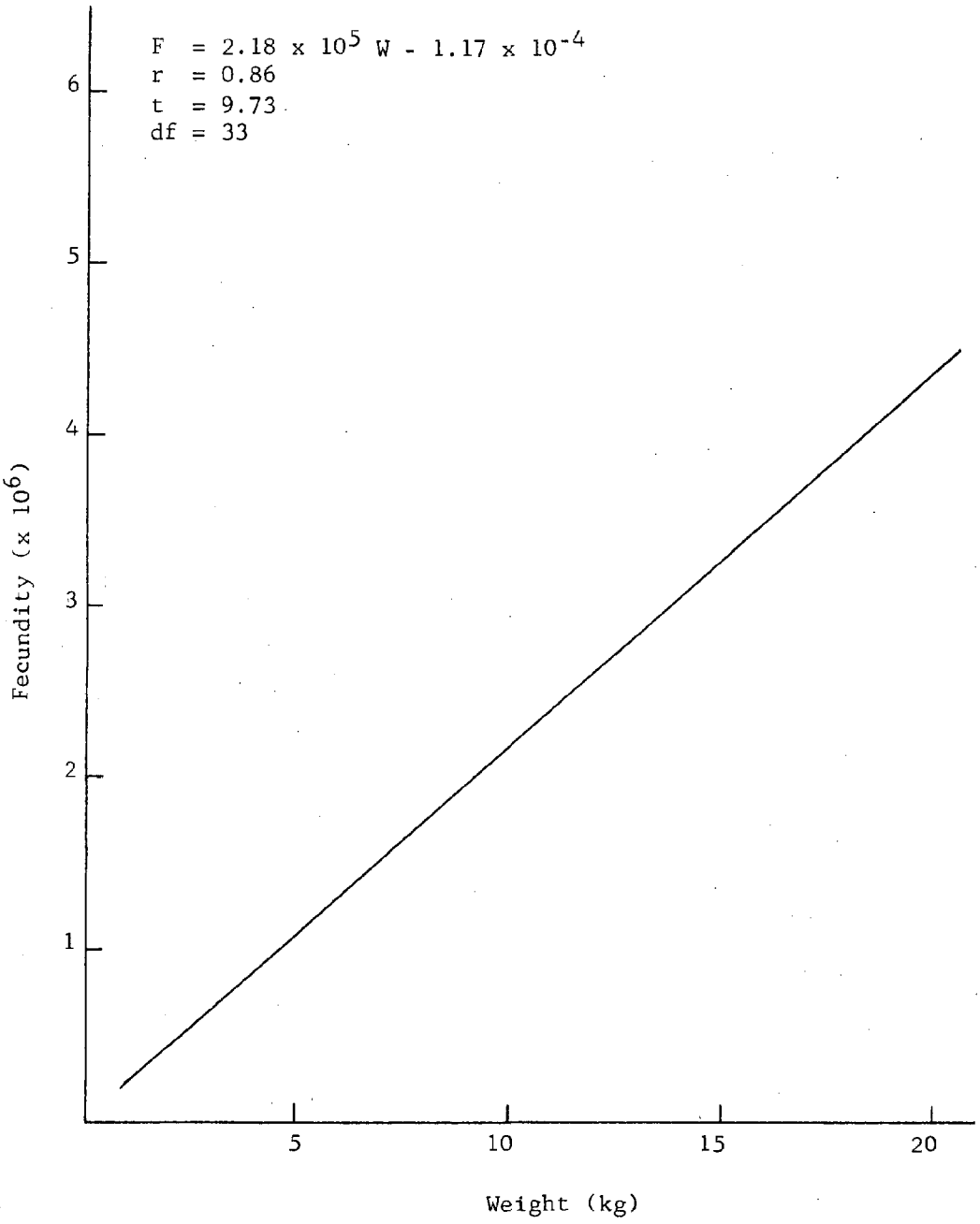


Figure 36.--Fecundity - weight relationship for 35 striped bass, offshore North Carolina, 1969 - 1971.

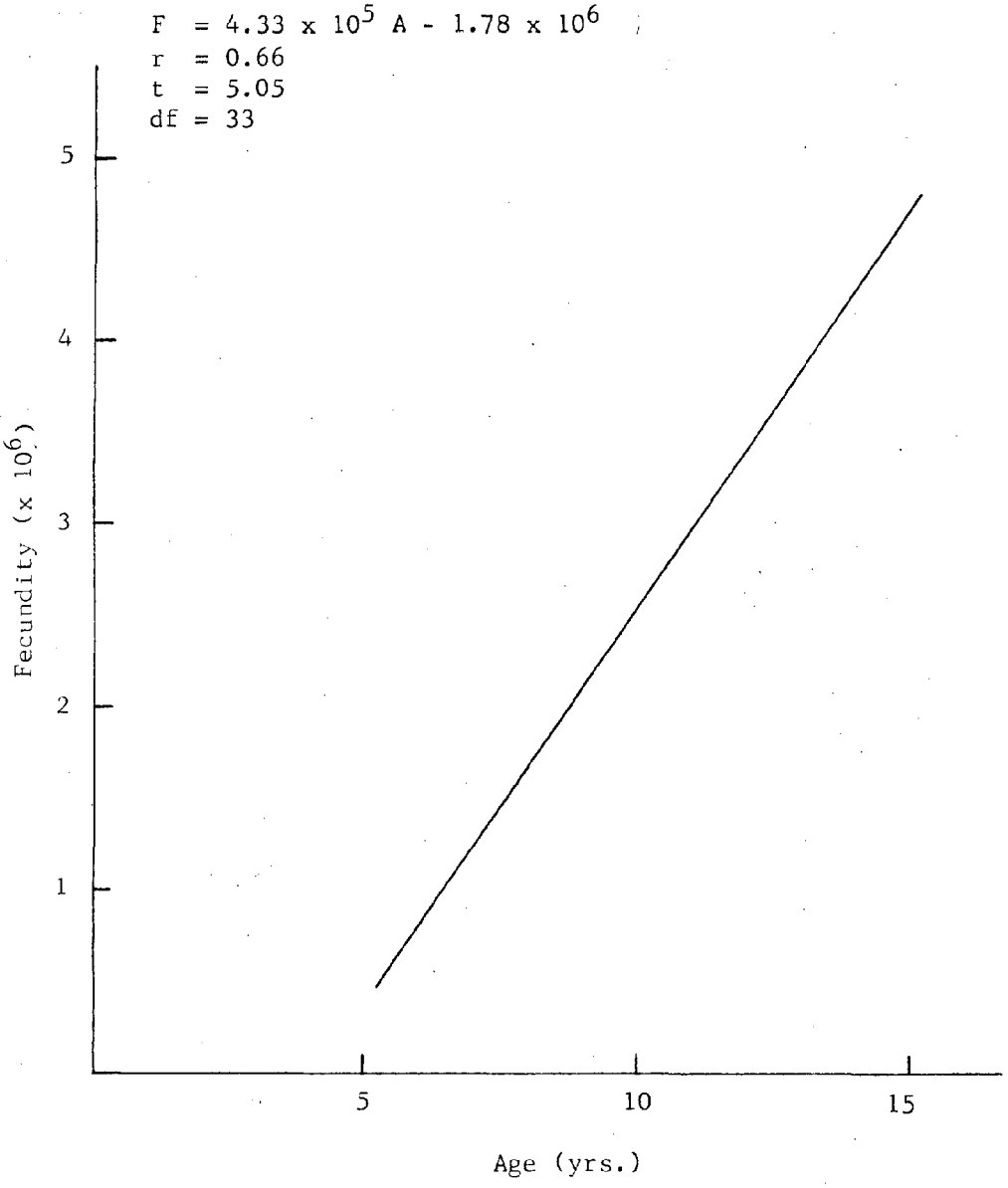


Figure 37.—Fecundity - age relationship for 35 striped bass, offshore North Carolina, 1969 - 1971.

American Shad - Fecundity was also estimated for 43 female American shad ranging from 42.0 to 50.6 cm fork length,and from 4 to 9 years of age. Estimated fecundities as well as other data from each fish are shown in Table 28.

The method of calculating fecundity was the same as with striped bass above. When the fecundity values obtained by the two methods were compared, a significant difference was found (paired comparisons d.f. = 42, t = 2.18*, and P = <.05 >.025).

Mean fecundity was 281,137; the range was 197,323 for a 5-year old fish to 457,530 fo a 9-year old specimen (Table 29). Lehman (1953) examined American shad in Hudson River and found fecundities ranging from 116,000 to 468,000 for fish 3 to 9 years of age. He found linear relationships and high correlation (>.9) between fecundity and length, weight, and age. Nichols and Massman (1963) also found linear relationships between fecundity and length, weight and age for fish from 4 to 7 years of age in York River.

In this study, significant relationships were also found between fecundity and fork length, weight, and age with T values of 4.56**, 4.22**, and 2.07* respecively (Figures 38, 39, and 40). Linear and curvilinear regressions were also computed between fecundity and spawning marks but no significant relationship was found at the 95 percent level.

Procedures similar to Jackson and Tiller (1952) for striped bass and Lehman (1953), as modified by Davis (1957), for American shad were utilized to determine total estimated fecundity. The above researchers determined total estimated fecundity by adjusting sample unit counts to represent a sample size of 1 gram. The total number of ova for each fish was then calculated from the sample unit mean and the total weight of the ovaries.

In this study, an actual total ova count for each 1-gram sample was taken. The total estimated fecundity for each fish was determined by calculating the number of

Table 28.—Age, fork length, weight and estimated fecundity of 43 American shad caught off the North Carolina coast, 1970 - 1971

Specimen number	Fork length (cm)	Weight (kg)	Age	Right ovary		Est. fecundity right ovary	Left ovary		Est. fecundity left ovary	Total est. fecundity
				Weight(g)	Ova/g		Weight(g)	Ova/g		
AMS-25	44.3	1.5	4	47	2,275	106,925	53	2,533	134,249	241,174
AMS-41	48.0	2.2	5	48	3,148	151,104	63	3,117	196,371	347,475
AMS-37	45.3	1.8	5*	46	1,882	86,572	57	1,943	110,751	197,323
AMS-14	47.4	1.8	5*	69	1,483	102,327	96	1,398	134,208	236,535
AMS- 3	42.0	1.4	5*	42	2,938	123,396	53	2,883	152,799	276,195
AMS- 2	45.7	1.7	5*	72	2,105	151,560	77	1,746	134,442	286,002
AMS- 4	44.5	1.6	5	48	2,097	100,656	52	2,036	105,872	206,528
AMS-16	45.2	1.7	6	77	1,533	118,041	60	1,732	103,920	221,961
AMS-42	48.1	2.2	6*	54	2,934	158,436	70	2,988	209,160	367,596
AMS-40	47.2	1.9	6*	59	2,693	158,887	79	2,717	214,643	373,530
AMS-48	46.5	1.7	6*	65	2,504	162,760	62	2,530	156,860	319,620
AMS-49	45.2	1.8	6*	56	2,421	135,576	65	2,318	150,670	286,246
AMS-51	48.7	2.2	6	104	1,645	171,080	93	1,764	164,052	335,132
AMS-20	43.0	1.5	6*	55	1,842	101,310	75	1,912	143,400	244,710
AMS- 7	45.6	1.7	6	80	1,514	121,120	90	1,625	146,250	267,370
AMS-27	44.5	1.6	6	68	2,033	138,244	78	1,757	137,046	275,290
AMS-28	48.7	1.9	6*	41	2,323	95,243	68	2,241	152,388	247,631
AMS-45	44.2	1.6	6*	67	1,773	118,791	88	1,647	144,936	263,727
AMS-23	47.2	2.1	6*	70	1,652	115,640	74	1,608	118,992	234,632
AMS-18	47.2	2.0	6	75	1,764	132,300	99	1,791	177,309	309,609
AMS-32	44.2	1.5	6*	60	2,131	127,860	68	1,975	134,300	262,160
AMS-39	48.5	1.6	6*	80	1,488	119,040	93	1,554	144,522	263,562
AMS- 5	48.5	2.0	6*	65	2,004	130,260	81	2,069	167,589	297,849
AMS- 9	43.5	1.4	6*	35	2,721	95,235	48	2,576	123,648	218,883
AMS-12	46.7	1.9	6*	54	2,051	110,754	63	2,058	129,654	240,408
AMS- 1	46.7	1.9	6*	58	2,861	165,938	59	2,967	175,053	340,991
AMS-35	46.0	1.5	7*	56	2,078	116,368	57	2,232	127,224	243,592
AMS-30	45.0	1.5	7*	65	1,869	121,485	71	1,868	132,628	254,113
AMS-17	47.1	1.9	7*	79	1,983	156,657	77	2,335	179,795	336,452
AMS-21	46.2	2.0	7*	73	1,499	109,427	89	1,514	134,746	244,173
AMS-24	47.6	1.8	7*	78	1,953	152,334	84	2,146	180,264	332,598

Table 28 (cont.)

Specimen number	Fork length (cm)	Weight (kg)	Age	Right ovary Weight(g)	Right ovary Ova/g	Est. fecundity right ovary	Left ovary Weight (g)	Left ovary Ova/g	Est. fecundity left ovary	Total est. fecundity
AMS- 6	44.2	1.6	8*	51	2,472	126,072	63	1,897	119,511	245,583
AMS-46	50.3	2.1	8*	52	2,070	107,640	65	2,591	168,415	276,055
AMS-33	50.6	2.3	9*	58	2,328	135,024	81	1,883	152,523	287,547
AMS-22	50.5	2.0	9*	78	2,911	227,058	88	2,619	230,472	457,530
AMS-26	45.6	1.6	--	49	2,138	104,762	63	1,906	120,078	224,840
AMS-47	43.8	1.6	--	43	1,880	80,840	51	1,891	96,441	177,281
AMS-34	45.2	1.5	--	60	1,804	108,240	63	1,562	98.406	206,646
AMS-11	43.7	1.0	--	41	2,149	88,109	52	2,209	114,868	202,977
AMS-19	49.2	2.1	--	102	1,441	146,982	98	1,358	133,084	280,066
AMS-10	47.6	2.0	--	85	1,821	154,785	91	1,703	154,973	309,758
AMS-50	46.0	1.7	--	91	1,413	128,583	105	1,228	128,940	257,523
AMS-36	45.4	1.8	--	74	1,821	134,754	86	1,778	152,908	287,662

* Scale had one or more spawning marks

Table 29.—Mean fecundity and range for each age group of 35 American shad from offshore North Carolina, March 1971

Age	Number of fish	Mean fecundity	Fecundity range
4	1	241,174	241,174
5	6	258,343	197,323 - 347,475
6	19	270,997	218,883 - 373,530
7	5	282,186	243,592 - 336,452
8	2	260,819	245,583 - 276,055
9	2	372,539	287,547 - 457,530
	35	281,137	197,323 - 457,530

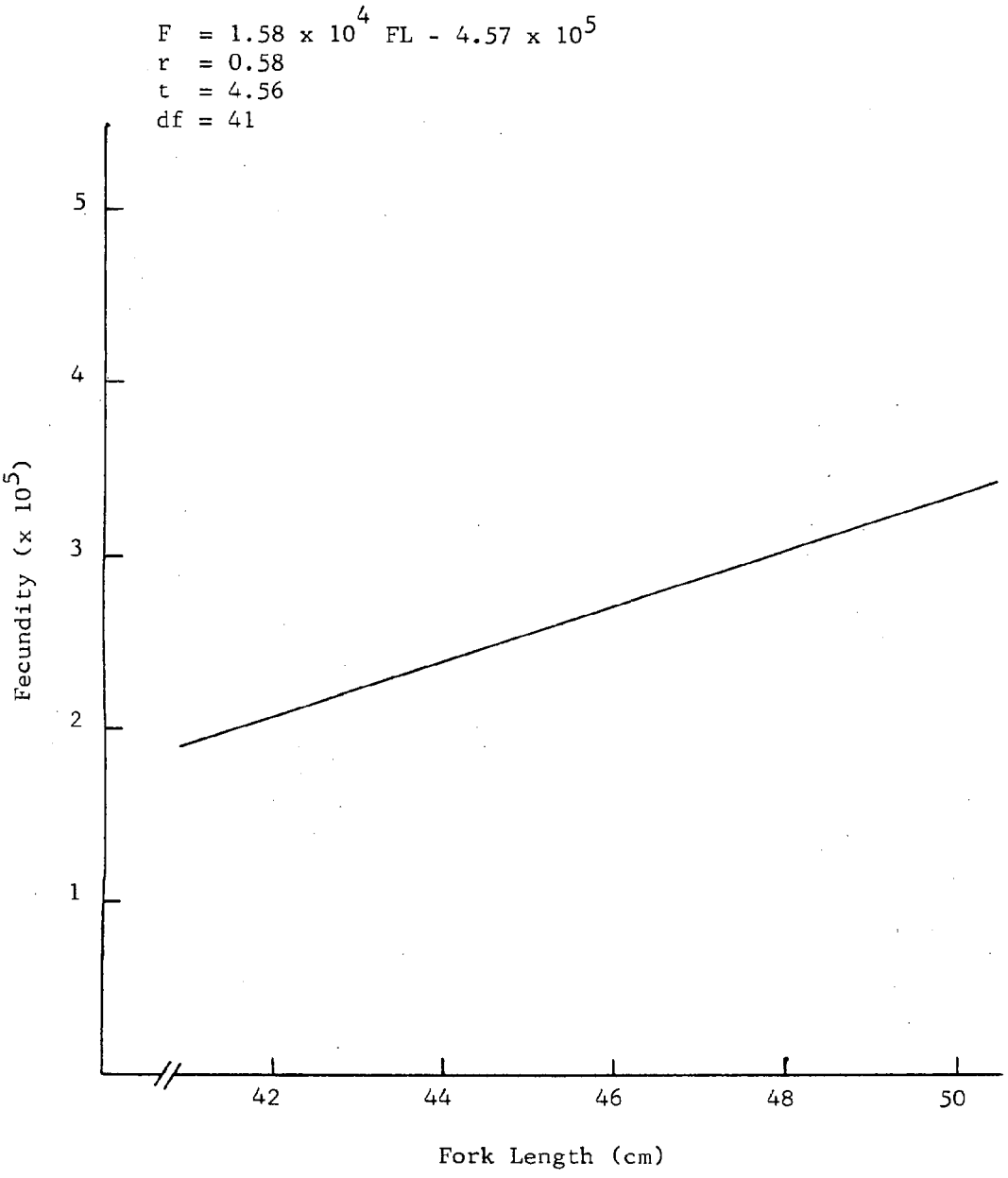


Figure 38.—Fecundity - fork length relationship for 43 American shad, offshore North Carolina, March 1971.

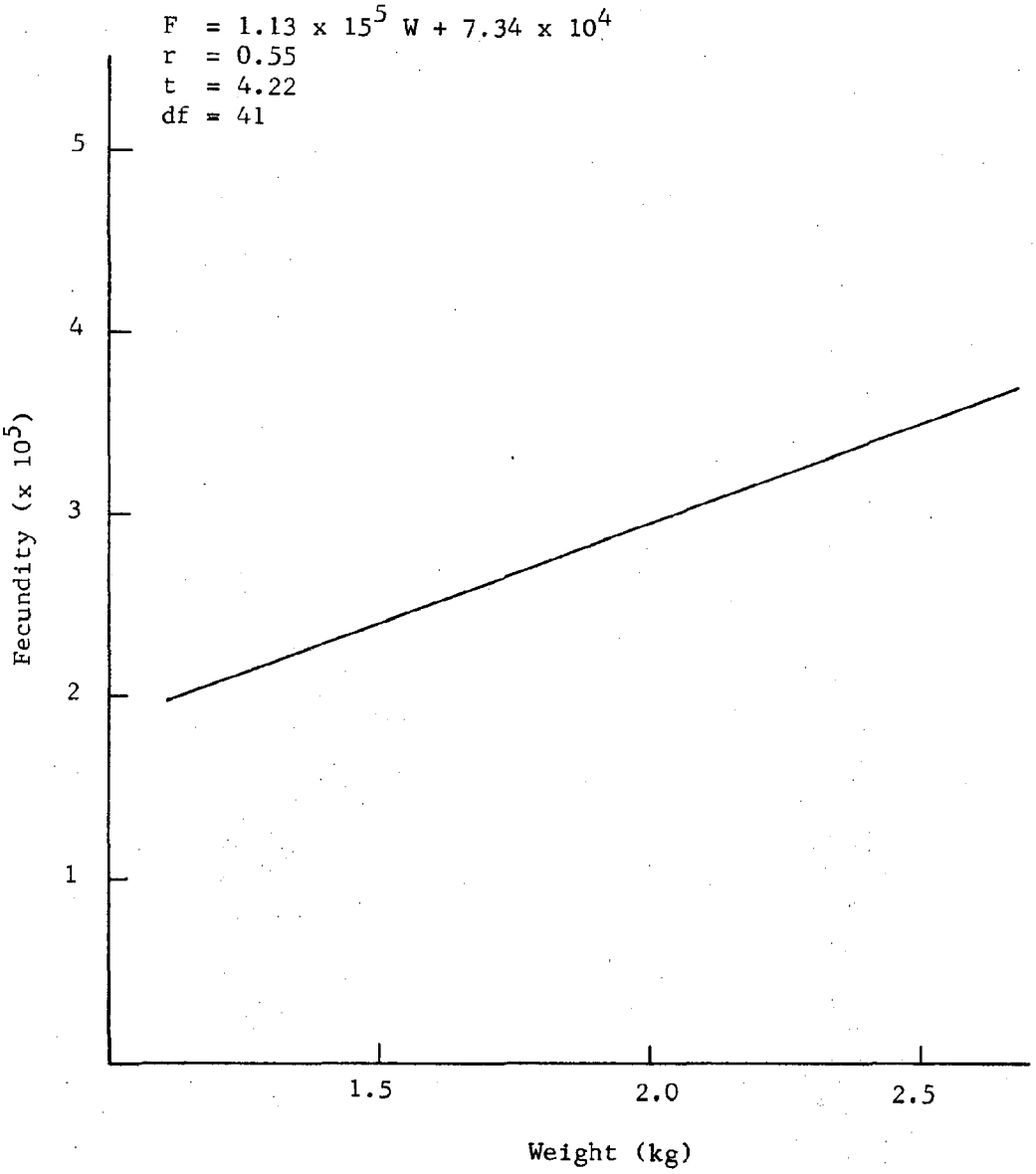


Figure 39.—Fecundity - weight relationship for 43 American shad, offshore North Carolina, March 1971.

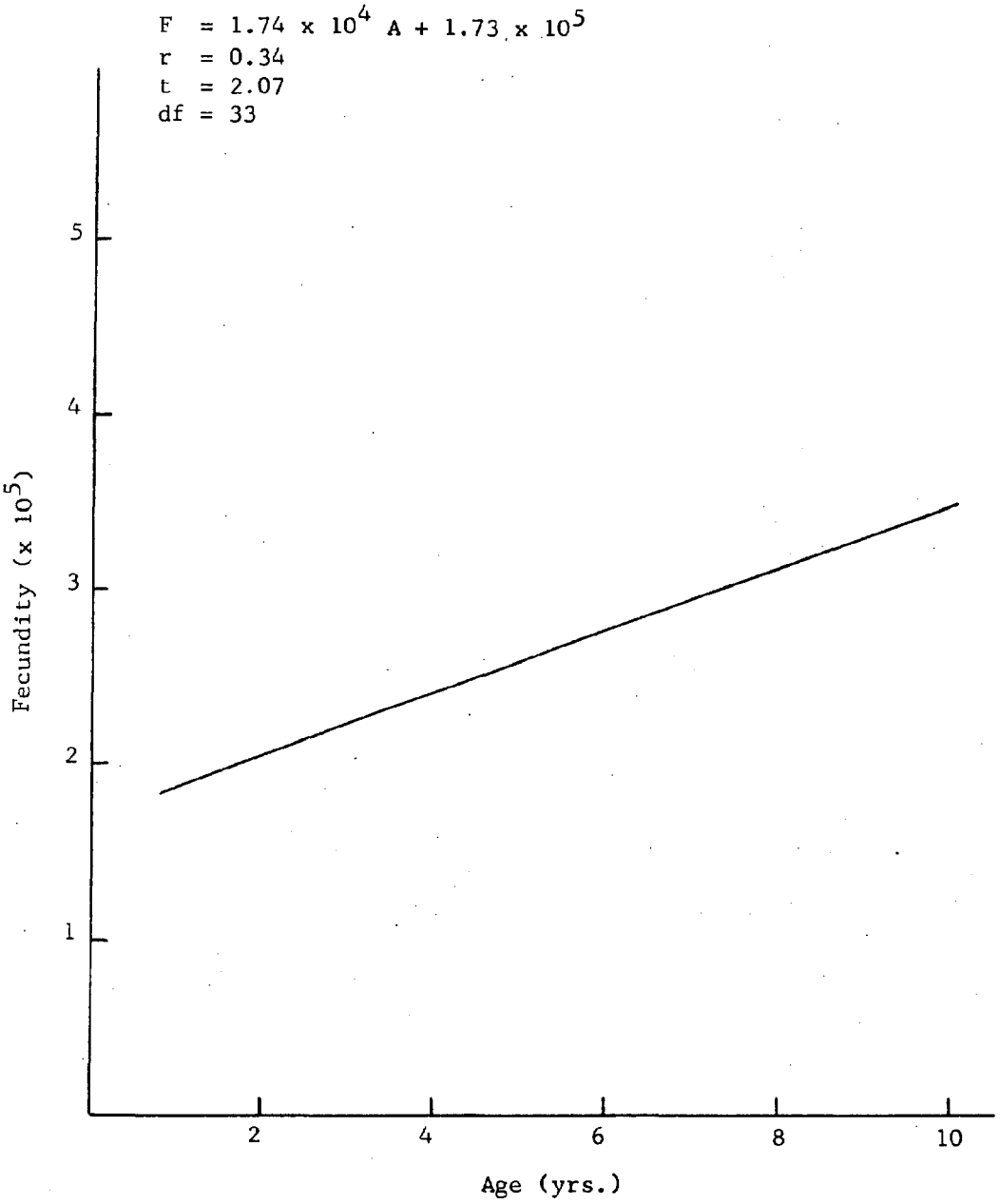


Figure 40.—Fecundity - age relationship for 35 American shad, offshore North Carolina, March 1971

ova per gram for every ovary, then multiplying that value by the weight of the respective ovaries. The estimated fecundities of the right and left ovaries were then added to obtain the total estimated fecundity.

When the total estimated fecundity values obtained by the two methods were compared, no significant difference was found for striped bass; however, a significant difference was found for American shad.

The fecundity method for American shad used in this study is thought to be better than Lehman's (1953) method as modified by Davis (1957) because it takes into account differences in size between the two ovaries of a given fish. The smaller ovary will generally have a greater number of ova per gram (58.8 percent of the time), and the larger ovary generally contains more ova (88.2 percent of the time). Thus, the number of ova contained in any ovary is more a function of the size of the ovary rather than a function of the ova size.

The method used by Lehman (1953) as modified by Davis (1957) generally results in higher total estimated fecundities than the method used herein. When a mean is computed for the number of ova per gram of two ovaries which are different in total weight, and the combined total weight of the two ovaries is multiplied by the mean number of ova per gram, the result will be considerably high. For example, American shad #33 (Table 28):

Right ovary:	Weight in grams - 58 # ova per gram -2328	Left ovary:	Weight in grams - 81 # ova per gram -1883

Lehman's method (1953 modified by Davis (1957)):

139 grams (total weight of both ovaries) 2106 (mean number of ova per gram = 292,734 (total estimated fecundity).

The method used during the present study:

58 grams = total weight of right ovary
81 grams = total weight of left ovary
2328 = number of ova per gram for right ovary
1883 = number of ova per gram for left ovary
135,024 = total number of ova in right ovary
152,523 = total number of ova in left ovary
287,547 = total estimated fecundity

As mentioned above, when the total estimated fecundity values obtained by the two methods were compared for striped bass, no significant difference was found. One can see from Table 26 when the numbers of ova per gram of each ovary are compared for striped bass, the differences are neglibible even for those striped bass captured during November (long before the spawning season) which had much higher ova per gram counts than fish captured nearer the spawning season.

The low fecundities of American shad found during the present study suggests female American shad sampled along the North Carolina coast were probably moving north to spawn in the New York-New England area rather than in North Carolina waters (Davis 1957). This supposition is further strengthened by examination of the scales of these fish, 77 percent had spawned previously, a phenomenon most commonly encountered in shad spawning in North Atlantic tributary rivers.

Sex and Female Maturity - Offshore

Random samples of 102 striped bass, 52 American shad, 362 blueback herring, and 72 alewife were taken from trawl catches and examined for sex and female maturity. Females were examined for maturity according to appearance of ovaries in the body cavity, a method similar to that used by Higham and Nicholson (1964) for menhaden. They gave five stages (I-V) ranging from immature (Stage I) to spent (Stage V). The arbitrary stages of maturity assigned in the field were as follows:

Stage I - Ovaries small, occupying only a small fraction of the body cavity. Ova invisible to the naked eye.

Stage II - Ovaries occupying about one-third to one-half of the body cavity. Ova invisible to the naked eye.

Stage III - Ovaries occupying about two-thirds of the body cavity. Ova visible through ovarian membrane.

Stage IV - Ovaries occupying about three-fourths or more of the body cavity. Ova readily separated from the follicles when the ovarian wall is pressed (ripe).

Stage V - Ovaries flabby, bloodshot, and occupying less than one-half of the body cavity (spent).

All females examined for maturity contained ovaries classified as Stage I, Stage II, or Stage III in maturity. Females dominated the striped bass, American shad, and alewife samples and male bluebacks dominated the blueback samples. Results are summarized in Table 30.

Sex and Female Maturity - Chowan River at Tunis

Random samples of 542 blueback herring and 387 alewife were taken from a series of seven pound nets on Chowan River at Tunis and examined for sex and female maturity. Samples were taken weekly.

Male blueback herring dominated samples from 21 March 1971 through 6 April 1971. However, sampling conducted on 14 April 1971 indicated the ratio of males to females had almost approached an equilibrium, with females dominant (52%). This was also the beginning of the peak spawning period for blueback herring, as reflected by percentages of ripe versus spent females. Beginning 14 April 1971 females dominated the samples and continued to do so until sampling was terminated. All females examined were either ripe or spent.

The same pattern is also indicated for alewife. Fishermen were cutting females for roe during the second and third weeks in March, and unculled samples were not available. All females examined were either ripe or spent. Results are summarized in Table 31.

Fishing Among the Foreign Fleet

Tows were made among the foreign fishing fleet during February and March 1971. One 40-minute tow was made on 15 February, sixteen miles east-southeast of the Virginia line, and 15 miles off Currituck Beach among 15-20 foreign fishing vessels. Two 30-minute tows were made on 16 and 17 March, 20-25 miles east of Currituck Light House among four East German vessels. Also, one 30-minute

Table 30.--Sex and female maturity of 52 striped bass, 52 American shad, 362 blueback herring and 72 alewife from offshore North Carolina 1970 - 1971

Species	Month	Tot. no.	No. males	Per-cent	No. fe-males	Per-cent	Female maturity*									
							Stage I	Per-cent	Stage II	Per-cent	Stage III	Per-cent	Stage IV	Per-cent	Stage V	Per-cent
Striped bass (Morone saxatilis)	Nov.-Mar.	102	12	11.8	90	88.2	18	20	--	--	72	80	--	--	--	--
American shad (Alosa sapidissima)	March	52	8	15.4	44	84.6	1	2.3	--	43	97.7	--	--	--	--	--
Blueback herring (Alosa aestivalis)	Dec.-Apr.	362	196	54.1	166	45.9	42	25.3	85	51.2	39	23.5	--	--	--	--
Alewife (Alosa pseudoharengus)	Feb.-Mar.	72	25	34.7	47	65.3	4	8.5	43	91.5	--	--	--	--	--	--

* See text for explanation of stages Page 117

Table 31.—Sex and female maturity, by week, of 542 blueback herring and 387 alewife from unculled samples at Tunis on Chowan River, North Carolina, 1971

Species	Week of	No. in sample	No. males	Per-cent	No. fe-males	Per-cent	Female maturity[1] Stage I	Per-cent	Stage II	Per-cent	Stage III	Per-cent	Stage IV	Per-cent	Stage V	Per-cent
Blueback herring (Alosa aestivalis)	3-21	20	18	90.0	2	10.0							2	100.0		
	3-29	19	18	94.7	1	5.3							1	100.0		
	4- 6	101	77	76.2	24	23.8							21	87.5	3	12.5
	4-14	100	48	48.0	52	52.0							22	42.3	30	57.7
	4-20	101	42	41.6	59	58.4							16	27.1	43	72.9
	4-27	99	30	30.3	69	69.7							5	7.2	64	92.8
	5- 4	102	34	33.3	68	66.7									68	100.0
Totals		542	267	49.3	275	50.7										
Alewife (Alosa pseudoharengus)	3- 1[2]	102	80	78.4	22	21.6							20	90.9	2	9.1
	3-23	124	53	42.7	71	57.3							21	29.6	50	70.4
	3-29	101	55	54.5	46	45.5							6	13.0	40	87.0
	4- 6	10	3	30.0	7	70.0							1	14.3	6	85.7
	4-14	30	7	23.3	23	76.7							2	8.7	21	91.3
	4-20	16	8	50.0	8	50.0									8	100.0
	4-27	3	1	33.3	2	66.7									2	100.0
	5- 4	1	--	--	1	100.0									1	100.0
Totals		387	207	53.5	180	46.5										

[1] See text for explanation (Pages 117-118)

[2] Unculled samples not available for weeks of 3-8-71 and 3-15-71

tow was made 55 miles east-southeast of Cape Henry, Virginia, amid 45-55 foreign trawlers and three foreign factory ships. The composition of the four tows made among the foreign fishing fleet is summarized in Table 32.

On 16 and 17 March an Irish three bridle trawl was used, and on 15 February a #41 Yankee trawl was used (Figures 5 and 7). The Irish three-bridle trawl appeared to be similar in design to the gear of the foreign vessels; however, the #41 Yankee trawl is smaller but more durable than the Irish three-bridle trawl.

A total of 346 blueback herring, 24 alewife, and 2 American shad were tagged and released in areas where a foreign fleet was fishing. As yet, no tags have been returned. In addition, 107 blueback herring and 18 alewife were saved for detailed biological analyses. The analyses indicated that 45 percent of the fish caught on 15 February were immature (Stage I, see "Biological Studies - Sex and Female Maturity" p. 117). Also, blueback herring averaged 20 millimeters smaller than the mean length for all blueback herring offshore North Carolina. This indicates the foreign fleet was catching immature fish on 15 February 1971. In the other samples, herring averaged about the same size and degree of maturity as the total offshore sample of herring.

Results of Preliminary Albemarle Sound Sampling

The primary objective of this preliminary inshore anadromous fish investigation was to determine the feasibility of surface (5-ft.plankton net with 1 mm mesh), midwater (experimental 3-bridle trawl), and bottom (shrimp and crab trawls) sampling gears for collecting anadromous species in the Albemarle Sound and its tributaries. It was anticipated that gear, methods, and techniques for sampling, developed during this preliminary investigation, would be utilized in an expanded research effort on anadromous fish to be initiated upon completion of this study.

Table 32.—Composition of catch made among the foreign fishing fleet offshore North Carolina, 15 February and 16-17 March 1971

Date and location	No. of samples	Species	No. of fish	Weight (kg)	Fork length (mm) mean	Fork length (mm) range
15 Feb. 1971: 16 miles ESE Va. line, 15 miles E Currituck Bch, N.C.	1	Blueback herring	254	51.0	213	167-250
		Alewife	17	4.0	251	215-283
		Sea herring		1.8		
		American shad	2	0.5		
16 Marh 1971: 55 miles ESE of Cape Henry Va.	1	Black sea bass	60	18.0		
		Weakfish	8	9.0		
		Summer flounder	4	4.5		
		Butterfish	170	6.8		
		Common searobin	1,950	164.0		
		Porgy	360	8.2		
		Boston mackerel	1,470	295.0		
		4 spot flounder	20	1.4		
		Sea scallops	350	5.5		
		Hake	60	11.4		
16, 17 Mar. 1971: 20-25 miles E. Currituck Light-house	2	Blueback herring	197	41.0	238	200-280
		Alewife	25	6.0	247	235-265
		Sea herring	9	2.3		
		Butterfish		6.8		
		Spiny dog fish	14	34.0		
		Cancer crab	20	4.5		
		Spider crab	20	3.2		
		Asteris		4.5		
		Squid		0.4		
		Windowpane	7	2.3		
		Atlantic mackerel		23.0		
		Clearnose skate	4	6.8		

Since sampling was conducted only during the last month (June 1971) of the final segment, no attempt was made to differentiate between the effectiveness of different gears. Trawling was often difficult because of numerous "hangs" consisting of stumps, logs, and broken-off and abandoned net stakes. However, 26 successful sampling stations were established and 32 samples were obtained in the Albemarle Sound and its tributaries (Figure 4).

For purposes of this report, Albemarle Sound is divided into eastern and western portions with the dividing line running from the west side of Perquimans River on the north, to the east side of Scuppernong River on the south (Figure 4). Samples taken in the mouths of rivers are considered to be from the sound rather than from the rivers.

Anadromous species appeared in samples of both eastern and western Albemarle Sound and all its tributaries except Scuppernong River.

Striped bass (140 to 266 mm) were taken in samples of both eastern and western Albemarle Sound and Perquimans, Little, Pasquotank, and Alligator Rivers. American shad (juveniles) were taken in eastern Albemarle Sound and North River. One juvenile hickory shad was taken in Roanoke River. Blueback herring (juveniles) were taken in Little and North Rivers and alewife (juveniles) were taken in Chowan and North Rivers.

SUMMARY AND CONCLUSIONS

Offshore North Carolina

Between 1 February 1968 and 1 July 1971, 1,038 trawl stations ranging in depth from 3 to 300 fathoms were taken by the R/V Dan Moore between Cape Roman, South Carolina and Cape Charles, Virginia.

Anadromous fishes totaling 9,734 were collected: 2,541 adult striped bass, 466 American shad (374 adults and 92 juveniles), 48 adult hickory shad, 4,104 blueback herring (3,711 adults and 393 juveniles), 2,375 alewife (2,202 adults and 173 juveniles), 190 Atlantic sturgeon and 10 shortnose sturgeon.

Striped bass and a few hickory shad were captured between Cape Lookout and the North Carolina/Virginia border. Blueback herring were captured from Beaufort Inlet to Cape Charles, Virginia. American shad and alewife were scattered from Hatteras Inlet to Cape Charles, Virginia. Atlantic sturgeon were captured mostly from Cape Lookout to the North Carolina/Virginia border with a few caught off Wrightsville Beach and Beaufort Inlet.

Striped bass were limited to depths of 10 fathoms and less. A few American shad were caught between 83 and 129 fathoms. Most American shad, hickory shad, blueback herring, and alewife were limited to depths of 20 fathoms and less.

Definite seasonal differences in abundance were noted in the ocean off North Carolina. Anadromous fishes were most abundant from December through March.

Fork length-frequency distributions were plotted for striped bass, Atlantic sturgeon, American shad, blueback herring, and alewife.

Random samples of striped bass, Atlantic sturgeon, blueback herring and alewife were weighed and measured. Curvilinear regressions expressing length-weight relationships are presented for each of these species.

Ages of 290 striped bass, 134 American shad, 76 blueback herring, and 50 alewife ranged from 2 to 15, 2 to 11, 2 to 8, and 4 to 8 years old, respectively.

Curvilinear regressions expressing the age-length relationships were calculated and plotted for each of these species.

Striped bass apparently develop an annulus from late October early November to late December early January. The peak annulus formation probably occurs in early December.

A total of 3,147 anadromous fishes was tagged. As of 1 November 1971, no tags had been returned from any of the 1,204 clupeids tagged. The recovery rate for Atlantic sturgeon was 8 percent, and tag returns indicated a southward coastal movement from November through January and a northward coastal movement after January. The recapture of 197 striped bass indicated striped bass overwintering off the North Carolina coast enter Pamlico and Albemarle Sounds, Chesapeake Bay, and move northward along the Atlantic coast to Maine during the spring and summer.

The mean monthly total and fishing mortality rates for the 1968 through 1971 fishing season were 24.3 and 3.6 percent, respectively. When the mean monthly fishing mortality rate was projected for a period of twelve months, an annual mortality rate of 35 percent was calculated. This percentage appears to be a better estimate of the annual harvest rate than the 11.2 percent "exploitation rate" determined from tag returns.

Stomach analyses of 102 striped bass indicated striped bass remain active and opportunistic feeders during the winter, feeding on a variety of fish and invertebrates. Stomach analyses of 45 adult American shad revealed they not only eat fish, but, on occasion, eat fish to the extent that they can be considered a major food item. Stomach analyses of 15 juvenile American shad revealed anchovies, a food item rarely encountered in such fishes.

Fecundity was determined for 35 striped bass between 7 and 13 years old. Total estimated fecundities ranged between 614,243 and 4,057,059. Linear

regressions expressing weight-fecundity, fork length-fecundity and age-fecundity relationships were calculated and plotted.

Examination of the gonads of striped bass, American shad, blueback herring and alewife revealed a predominance of female striped bass, American shad, alewife, and male blueback herring in the ocean off North Carolina. Ovaries of females ranged from immature to maturing. None were ripe or spent.

Sampling among foreign fishing vessels revealed that the East Germans and others were taking anadromous fish off the North Carolina coast.

Albemarle Sound and Tributaries

Fork length-frequency distributions were plotted for male and female blueback herring and alewife on the Chowan River at Tunis.

Random samples of blueback herring and alewife taken at Tunis were weighed, measured and sexed. Curvilinear regressions expressing the length-weight relationships, by sex, were calculated and plotted for each of these species.

Scale analyses of 40 male and 26 female alewife, taken at Tunis, indicated these fish ranged from 3-8 and 4-8 years old respectively. Scale analyses of 36 male and 32 female blueback herring taken at Tunis indicated these fish ranged from 4-7 years old. Curvilinear regressions expressing the age-length relationships were calculated and plotted by sex.

Examination of gonads of blueback herring and alewife revealed males were dominant before the spawning peak. A near equilibrium was indicated during the spawning peak. Females were dominant after the spawning peak. Ovaries of females ranged from ripe to spent.

Twenty-six successful sampling stations were established in the Albemarle Sound and its tributaries. Anadromous species were taken in all areas sampled except the Scuppernong River.

MANAGEMENT IMPLICATIONS

Results presented herein indicate a large population of overwintering "jumbo" striped bass are available to the North Carolina oceanic trawl fishery. At the present time, this resource is largely unexploited except for those fish caught by New England sports fishermen after the spawning season. The majority of North Carolina trawlers apparently are incapable of fast towing speeds with gear suitable for taking significant numbers. The exception is a recently introduced fishing method called "pair trawling", wherein two trawlers tow one large trawl between the two boats at higher than normal rates of speed. An example of the incapability of most commercial fishing trawlers was demonstrated by the R/V Dan Moore. With efficient gear and greater towing speeds, the vessel caught commercially significant quantities of "jumbo" striped bass (mostly large females with roe) while fishing among commercial trawlers taking few or no striped bass.

With anticipated developments in increased efficiency of gear and fishing methods, the "jumbo" striped bass population overwintering off the North Carolina coast could be exploited to the extent that the sports fishery for this species from North Carolina to Maine could be seriously endangered. The desirability of encouraging an increased commercial effort on large striped bass is questionable. Consideration of uniform regional regulations (North Carolina to Maine) regarding this population of large striped bass appears desirable. In addition, an increased effort to obtain reliable catch statistics on a regional basis is necessary to determine if this population of large striped bass is being harvested at or near a sustained level.

It appears the majority of these large striped bass are females. If catch statistics show a continual decline, drastic measures would be required immediately to afford protection to this valuable resource.

Striped bass tagged while overwintering off the North Carolina coast were recaptured from North Carolina (Albemarle and Pamlico Sounds) to Maine. Similarities between offshore and Chowan River samples of river herring were also found. More definite tagging programs will be required on anadromous species in Albemarle and Pamlico Sounds during the fall and spring (after the spawning run) to determine to what extent anadromous fish in these areas actually contribute to Atlantic coast (offshore) populations. More definitive tagging and biological studies, such as species and year class composition and mortality, should be conducted on river herring offshore and in the various estuarine waters of North Carolina to determine to what extent those fish found offshore contribute to North Carolina and other populations along the Atlantic coast. Similar work should be done on American shad to better define the relationships of the offshore and inshore stocks.

Since it was determined that foreign fishing vessels were taking anadromous fish off the North Carolina coast, a continued monitoring effort to determine what effects, if any, this fishing pressure may be having on domestic catches in North Carolina estuarine waters will be required. Major efforts should also be expanded in gear research to accomplish this objective.

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